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The Chicago Harbor Controversy.

It certainly is a bit cruel that the Secretary of War should be obliged, at a time when he is so busy repairing his political fences and setting snares for delegates, to reach a decision in the Chicago Harbor controversy. The main facts of this controversy are quite simple. The Commercial Club of Chicago, a very influential organization, has been working for some time to devise an elaborate system of parks and connecting boulevards which will be to the advantage of the aesthetic appearance of the Illinois metropolis. As a part of these plans, which are being prepared under the direction of Mr. D. H. Burnham, it is proposed to convert all of the lake front from 12th St. southward into a magnificent system of parks and driveways. Just north of 12th St., Grant Park has already been laid out. It is also proposed to build docks on the lake front just north of the Chicago River, for the accommodation of lake shipping that does not utilize the Chicago River. The park commissioners of the city have already obtained legislative sanction for these plans and the only thing that stands in the way of their execution is the consent of the Secretary of War to the permanent abandonment of the long stretch of lake front to the south of the Chicago River for all commercial purposes. Everything was progressing nicely with the project until Jan. 6, when Mayor Busse drove a large spike into it in the shape of a communication to the city council asking authority to appoint a commission to consider the conversion of the lake front from 12th St. south to Jackson Park into a harbor frontage, with a long series of docks protected by a breakwater, which would also serve as a railroad terminal. The city council promptly authorized the mayor to appoint such a commission and appropriated money for its use. The mayor also sent to Secretary Taft a letter urging him to defer any action on the application of the park commissioners for permission to use the lands in controversy until he, the mayor, had an opportunity of speaking against that project and in favor of his own.

It is thus evident that two influential bodies of Chicago citizens have submitted to Secretary Taft one of the most far-reaching problems which has yet arisen in connection with the commerce of the Great Lakes. The vital importance of this problem can only be appreciated after a careful study of various reports on the city's water-borne commerce which have been made from time to time by members of the Corps of Engineers of the army. At the present time Chicago is the fourth in importance of the ports on the Great Lakes. There are a good many reasons for the gradual decline of the city's relative position among these ports, but there can be little question that one of the reasons is found in the inadequate facilities afforded by the Chicago River. At the present time the stream is unable to accommodate the vessels which the commerce of the city would naturally bring to it. As a result of this congested condition some industries which would naturally remain in Chicago have moved away and others have been more or less hampered. This has been due to an attempt to make the narrow river serve as a sewer, as a wharfage area and as a waterway for the free passage of boats. According to reports of engineer officers stationed at Chicago, the river, even after enlargement to 200 ft. width and 26 ft. in depth in accordance with the plans of the Sanitary District, will have all it can do to fulfil properly any one of these three functions, and it cannot reasonably be expected to fulfil properly any two of them, much less to fulfil all three together.

It is needless to go into the details of the figures upon which these statements are based, as they have been given in documents submitted to Congress. The significant fact about them is that the lake commerce of Chicago needs a careful consideration which it evidently has not yet received. It is idle to suppose that the Commercial Club of that city would have been willing to father a proposal to restrict the lake harbor facilities for all time to a comparatively short strip north of the Chicago River unless it had given some attention to the matter. On the other hand it is equally evident that the Mayor of Chicago would not urge the Secretary of War to withhold his consent to a park system designed to beautify the lake front were he not convinced that his substitute plan of a series of lake front wharves south of Grant Park was essential for the growth of Chicago's water-borne commerce. It is an unfortunate fact that while railroad companies look far into the future in their plans for developing their business in an important city, there is nobody to look far into the future for water-borne commerce. While there may be associations of ship owners and associations of shippers, they do not have the vital interest in the problem of securing control of water front properties that the railroads have in securing control of terminal properties. There is hardly a city on the American seaboard which is not suffering from the shortsight of our forefathers in neglecting to acquire absolute control of the portions of its water front needed for commerce. It would be a great pity, therefore, to see this question of a Chicago lake front harbor settled by a hasty judgment. The location of that harbor is a problem of extreme difficulty, involving a consideration of present and future conditions in shipping which merit the gravest thought.

The Railroad as a Peace Agent.

Those readers of The Engineering Record who are interested in affairs of state will recall that Secretary Root recently referred to the Central American Peace Conference, held a few weeks ago, at Washington, as one of the most important gatherings of an international character in recent years. The Central American states have long suffered from the intermittent revolutions and interstate wars which have become a source of amusement to all not directly concerned in the development of some business or industry there. To people who have embarked upon commercial ventures in the Central American republics, these struggles are by no means humorous; in fact, they are extremely serious. Until they are abated and tranquility is assured, the extraordinary richness of these lands will remain undeveloped. This fact is well recognized by the leading men of these countries, and there has been a steady, although somewhat slow, progress toward tranquility and better administration, broken at intervals by the wasteful struggles due to the ambition of some politician. The United States necessarily is obliged to exercise a sort of protection over the countries in question, not only in order to guide the development of their resources, but also to prevent any entanglement between them and European nations which will result in diplomatic difficulties. The Department of State has always felt this oversight was a serious problem. It is very difficult to keep in touch with affairs in a country which is practically isolated from the rest of the world through lack of communication with it, or depends for such communication upon a railroad controlled by some single industry. The late James G. Blaine recognized that until these Central American Republics were opened up by railways and other means of communication they would be too isolated to play the part in the world's affairs that their resources and positions warranted, and it was on this account very largely that the famous plan of a Pan-American railway was suggested.

At the recent Peace Conference the Costa Rican delegation again brought forward the suggestion that the construction of a railway linking together all the Central American republics would be the best unifying influence which is practicable. Messrs. Luis Anderson and J. B. Calvo pointed out in considerable detail that in those Spanish-American countries where railway development had been most marked, progress had also been most apparent in agriculture and the industries. This is, of course, noticeable in Mexico, where the construction of railway systems has always been fostered by the Diaz government, but it is equally noteworthy in the Argentine Republic, where the development in the last fifteen years has been enormous, and in Brazil and Chili. Intercommunication brings with it better acquaintance, and with better acquaintance comes, as a rule, a reduction in feelings of distrust. Better methods of communication also enable a central government to become stronger and to exercise its powers for the greater advancement of the interests of its citizens, so that it is not at all surprising the delegation from Costa Rica emphasized the importance of railway intercommunication between the Central American states as one of the most important methods of insuring peace and promoting welfare in that section of the continent.

Accompanying their statements was a paper by Mr. Theodore Paschke, who has had a long engineering experience in Spanish-American countries, and was connected with the surveys for the Pan-American railway. This paper is printed elsewhere in this issue. It has already attracted much attention as a decidedly unique engineering document. It is gratifying to state, also, that the criticisms of Mr. Paschke's paper, so far as they have been seen by this journal, are distinctly favorable, which is not at all surprising when the improvements that have followed the construction of railways in unsettled portions of the United States are kept in mind. It is only necessary to recall the history of the Black Hills to fully appreciate what the railway has meant to the Dakotas. There are many men who emphatically refuse to be considered old who can recall when Deadwood was merely a collection of rough huts and Spearfish was an inferior saw-mill and a few shacks only. Later this region developed into a typical mining camp of the roughest character, where a man's life was not worth as much as a horse, and saloons ran twenty-four hours a day for seven days in the week. With the coming of the railway these conditions disappeared, just as they have disappeared everywhere else with the advent of the locomotive. It would hardly be worth while recalling them were it not for the fact that some of the men who engaged in one kind of work or another on the frontier during the days of railway pioneer work have since taken up business in Central America, and one and all agree that the conditions to the south of us are by no means as bad as they were on the outskirts of civilization when our Western states were being settled about a generation ago. It was the railroad which did the good work in these Western states, and it will probably be the railroad which will accomplish the development of the Central American states. A good beginning has already been made in such a railway system, and its further development into a complete line from Mexico to Panama is one of the most desirable things this country can undertake for the benefit of its sister republics.

The Management of Sewage Disposal Plants.

Through the courtesy of the New Jersey Sewerage Commission this journal is able to print elsewhere in this issue an important paper on the disposal of sludge, recently written for that body by Mr. Geo. W. Fuller. In this paper Mr. Fuller emphasizes a fact that has been repeatedly stated in The Engineering Record. This is the importance of managing sewage disposal works, particularly small works, in such a way that they will give satisfactory results. As experience with such plants is gained, it appears more and more certain that the well-managed plant which is only fairly well designed will give an effluent of a better character than a well-designed plant which is not operated intelligently. The marked tendency to allow disposal works to run themselves in a happy-go-lucky way is a natural outcome of the laissez-faire spirit which has until recently prevailed regarding the disposal of all municipal wastes. So long as any of these waste products was dumped or discharged at some point where it did not cause offense nobody cared anything about the matter. When sanitary science showed that these methods of disposing of the materials were likely to result in an increase in the sick rate, or when people were subjected to nuisance on account of the odors which arose from the gradually increasing amounts of refuse deposited in their vicinity, steps were taken with more or less reluctance to construct disposal plants. Sometimes these have been designed by engineers and sometimes the promoters of patented apparatus have talked the city authorities into purchasing their systems. In either case, the works have generally been left to run themselves after they were constructed. In many small places the attendance at the works has been merely nominal and in larger places the management has too often been left to day laborers or wholly incompetent superintendents. The results have been generally unsatisfactory.

The actual management of a sewage disposal plant is not likely to be a troublesome matter. Unless the sewage fluctuates in character considerably it is generally practicable to determine a system of management for the works receiving it which is practically a cycle of repeated simple operations. It is desirable, however, that the general oversight of the operations should be entrusted to some specialist, for only in this way can the results obtained be carefully checked and tendencies toward inferior working be detected promptly. Moreover, as sewage disposal is a rapidly progressive art, a specialist who keeps in constant touch with progress in it throughout the world is more likely than anybody else to be able to suggest improvements in the methods of management enforced. An examination of the paper by Mr. Fuller will show how many points there are connected with the operation of a small sewage disposal plant in which lack of attention or lack of knowledge on the part of the manager may lead to trouble. There are some sections of the country, particularly Northeastern New Jersey, where it is often desirable to locate sewage disposal plants fairly close to houses, and it is needless to say that here the enforcement of the suggestions made by Mr. Fuller becomes absolutely essential. The carelessness and neglect which have characterized the management of too many small disposal works in this country cannot be tolerated at plants near houses. If these works are properly managed, which is not necessarily an expensive thing, they will be entirely free from nuisance; if they are improperly managed, then the towns failing to operate them properly will be harassed by suits for damages.

Attention is called to this matter because the remedy for the difficulty is one of such an elementary simplicity that it is surprising it has been so very rarely adopted. The average sewage disposal works in this country is quite a small affair, and it is entirely impracticable to employ in its operation men of technical training. Fortunately it is needless in plants of this sort to engage experienced chemists and bacteriologists to conduct the operations properly. The actual work to be done is of the simplest routine character, while the sampling of the sewage and effluent and the manipulation of certain elementary tests are readily done by men without any knowledge of chemistry. In order, however, for this work to be successful, it must be under the general supervision of some thoroughly experienced specialist, and any failure to omit this supervision will in all probability result in a failure to secure proper results from the works. The supervision is not necessarily an expensive matter, as before stated, since it involves generally only a comparison of the results of the successive tests furnished by the attendant at the plant and an occasional visit to the latter. Such supervision is best exercised, as a matter of course, by the designers of the works, and it is by retaining them for this purpose that the smaller communities of the country will be able to solve the problem of sewage disposal most satisfactorily. In the past there has been some hesitation on the part of consulting engineers to assume this responsibility, but now that the necessity for it has been more generally recognized by the authorities of towns and cities and the employees at the disposal works are of a better class than before, this reluctance on the part of specialists about supervising in a general way the works they plan is disappearing. In one sense it is a rather troublesome and profitless task, but on the other hand it is a business advantage in that it enables the consulting engineers to refer those coming to them for advice to plants built under their direction which are operating in a satisfactory manner.

Notes and Comments.

The Lack of Good Roads over the few miles of marsh separating Newark, N. J., from the Hudson was mentioned a few weeks ago, and it is rather interesting to recall the matter because the city of Rome, similarly isolated for centuries from the seacoast only fifteen miles away, has just begun the construction of a grand highway to the Mediterranean. It is expected that this will be finished in 1911 and that the people of the Italian capital will find the same pleasure and profit in it that the old Romans did in their road to Ostium, when that place was the headquarters of the imperial fleet. The new road is to be a great boulevard, with an electric railway and ample room for fast automobile traveling. Rome is only twice as large as Newark, and the importance of the travel over the boulevard to the sea will by no means equal that which would pass over a decent road from Newark to the Hudson.

A Very Bad Fire occurred last week in the Parker Building, a structure about 150 ft. high, at Fourth Ave. and 19th St., New York, almost over the subway. The building was completely gutted, four men were killed and about a dozen were seriously injured. When it was built about twelve years ago it was intended for offices, but was converted for other business purposes after construction. It is this shifting in class of occupancy of a building which is the source of one of the bad features of both the present and proposed building codes. The results of the fire show that the Parker Building was in no sense the kind of structure which an owner or tenant, desirous of securing the best accommodations, can now obtain. The interesting lesson of the fire, however, is an indirect one. This building was typical of many throughout New York and was far inferior in fire-resisting characteristics to structures like the Thirty-ninth Street Building, the Robert Gair Building, the Commercial Trust Building now under construction, and others of reinforced concrete, yet the proposed new building code for the city, if adopted, will prevent the erection of the latter type while permitting the construction of the former, if a favored method of fireproofing is employed in connection with it

The Swelling of Cast Iron by heating, a matter of interest in connection with the difficulties experienced with fittings in superheated steam lines, is indicated by tests made by A. E. Outerbridge some time ago, in which cast-iron bars were made to increase 40 per cent. in volume. A bar measuring 1 in. square by 14 13/16 in. long was heated in a gas furnace to 1450° Fahr. and thoroughly cooled 27 times, after which careful measurements showed that the bar had increased in length to 16½ in. and to a cross-section 1⅛ in. square. Further heatings increased the size of the bar only slightly. As this action is identical with the action of cast iron in superheated steam line fittings, it is quite generally thought that the latter phenomenon is the direct result of the many variations of temperature rather than the mere high temperatures in themselves. In many plants in which trouble has been experienced, variations of superheat temperature are constantly experienced through a range from no superheat when cleaning fires up to about 150° superheat under overload conditions, with frequent changes of as much as 50° within very short periods.

Aeronautic Engineering scored a great triumph on Monday of this week when M. Henri Farman won the Deutsch-Archdeacon prize of $10,000 by guiding an airship heavier than air back and forth over a course giving a total length of flight of 1 km. The trip was made under the direction of the Aero Club at Issy, near Paris, and lasted 1 min. 28 sec., during which a speed of 24 miles an hour was attained. The aeroplane ran about a hundred yards before rising from the ground, and it was a dozen feet or so in the air at the starting line. When it sailed across the field, it averaged about 25 to 30 ft. above ground, but descended somewhat in rounding the outer mark of the course, 512 m. from the start. After making the turn the aeroplane righted itself promptly and at the end of the run descended gently to the ground. It weighs 300 lb. and is driven by an eight-cylinder 50-h.p. motor weighing 176 lb. M. Farman had previously made successful flights with this aeroplane and on Nov. 11 his flight fulfilled the conditions of the Deutsch-Archdeacon prize, but as no members of the official committee of the Aero Club were then present he could not be given the trophy. The construction of the motors and frames of these machines calls for the highest mechanical ingenuity and skill, and such flights as M. Farman has been making are even more important indications of progress in mechanical engineering than the high-powered light-weight automobiles now so common.

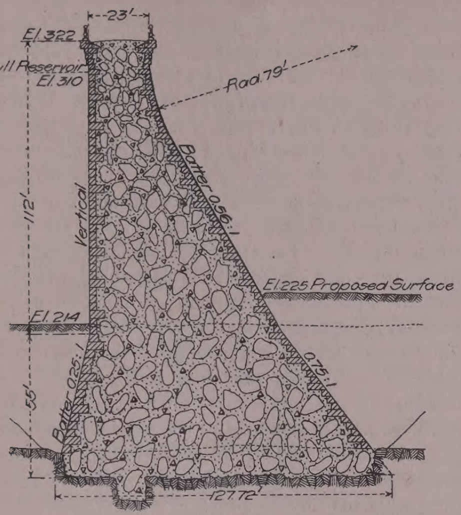
The Electrification of Steam Railways is discussed by the Massachusetts Railway Commission in its report just submitted to the legislature in terms so significant that they are given here unchanged: "The source to which the public may rightfully look for final relief from the smoke nuisance is the use of electricity as a motive power and the abandonment of steam locomotives. The recent successful installation of electricity on railroads in this country and in foreign countries has removed all doubt as to the practicability of its use for the transportation of passengers. There only remains for demonstration the type to be installed which will provide the public with a safe and reliable service at the lowest cost obtainable. The time is fast approaching when electricity as a motive power must be installed on railroads operating in and about Boston, at least, and to that end the work of preliminary investigation should be consummated, that the situation may eventually be met with intelligence and despatch. We therefore recommend further that studies be prosecuted and completed at the earliest possible date relative to the whole question of electric installation." The Commission is everywhere recognized as one of the most conservative bodies of its kind in the country, and this statement from it, following close upon the electrification announcement of General Manager Smith, of the Boston & Albany R. R., which was reported in the Current News Supplement of this journal on Nov. 16, 1907, is a sign of the times of far more significance than a sheaf of technical papers on purely engineering features of such work.

A Help to Contractors in driving a complicated lay-out of piles was described a fortnight ago in this journal in connection with the temporary jackknife drawbridge over Bronx River, and deserves the attention of those interested in pile-driving operations. The assembling on one sheet of all the information necessary for the work, such as the location of the bents, the spacing of the piles, the cut-off and a proper order for driving, will certainly result in fewer erors and consequently less loss of time in pulling piles, than where the information is given in three or four separate sheets or note books. The advantages of the driving program were shown so clearly at the first of the jackknife bridges than the contractor requested the engineer to draw up a similar one for the construction of the second bridge. Not only is time saved in moving the pile driver, but all danger of fouling it is avoided. A similarly commendable scheme was also drawn up by Mr. L. D. Fouquet, assistant engineer at the temporary bridges, for the Pelham Bay trestle which was described in The Engineering Record of Nov. 9, 1907, in connection with the six-tracking of the Harlem River Branch of the New York, New Haven & Hartford R. R. All of the data for putting in a six-track pile trestle containing 150 bents of 36 piles each were given in one sheet of moderate dimensions and so complete and accurate was the information that no other directions were necessary.

The Terrible Colliery Disasters that have lately shocked the country become still more terrible in view of the assertion by Dr. Joseph A. Holmes, in Bulletin 333 of the U. S. Geological Survey, that experience in the deeper and more dangerous coal mines of Belgium and other countries not only indicates that these American mine accidents may be reduced to less than a third their present number, but also gives promise of their practical prevention. It is deplorable to learn from a government scientist that the coal-mining methods of America are less safe than those of any other country, particularly in view of the fact that over two thousand men were killed and five thousand more were injured in our collieries during 1906. This was 3.4 men killed for every thousand employed. The statistics collected by representatives of the Geological Survey show that in Belgium in 1906 the number was 0.94, in Great Britain it was 1.29, in France it was 0.84 in 1905, and in Prussia it was 1.8 in 1904. The numbers of American coal miners killed and injured in 1906 by different causes is stated as follows: Gas and dust explosions, 228 killed and 307 injured; powder explosions, 80 and 215; falls of roof and coal, 1,008 and 1,863; other causes, 732 and 2,192. What makes these figures more shocking is Dr. Holmes' further statement that in no other country in the world are the natural conditions so favorable for the safe extraction of coal as in the United States.

Steam Shovel Excavation has been the subject of so much attention lately that the letter concerning the cost of it, printed elsewhere in this issue, deserves careful consideration. The writer has had responsible control of so much work of this character that what he states is authoritative. Any man who is charged with the duty of making a large shovel contract pay a profit has more than an academic interest in the work, for upon his success or failure depends his very bread and butter. It is therefore instructive to notice in this communication, as in others that have appeared in this journal, the familiar warning against placing much reliance on published statements of the cost of executing such work when making up tenders for new works. It is an easy thing to figure what the cost of doing the simpler parts of any common kind of construction may be, but it is much more difficult to estimate what the accessory works will cost, and it is these accessory works that are likely to make or break a contractor. That engineers are also liable to make the same omissions is shown by the fact that the new revised estimate of the cost of the Panama Canal is about 45 per cent. more than the estimate which was submitted to Congress to influence it to adopt the lock type of canal. In the case of a steam shovel anybody not an idiot can keep a time schedule of the actual movements of the machine and of the work done by each of the men, but it takes judgment and experience to know when all the items of cost mentioned by Mr. Stilson are kept down to the minimum consistent with a minimum total cost. It is most important to bear in mind that it is not always best to look at each step in a complex series of operations as if it were a wholly independent piece of work, for total cost is made up of many items and the degree to which a saving is desirable in any one item depends in part upon the effect of such saving upon the amount of other items.

Track Arrangements for minor stations on a single-track line are brought up again in the letter from Mr. Foote in this issue. It is a subject that deserves much study, for with the growth of towns and railway traffic which takes place everywhere, the arrangements to be seen in many of the little stopping places along our railways must soon be outgrown. The time to do away with them is manifestly when the work can be done most economically, and with the reduction in wages and in numbers of men engaged in steady work that is now in evidence it would seem as if the season about to open would be a good one for trying out some of the plans that have been suggested. It is manifest that there are two things to be kept in mind. The first is that nothing should be adopted which will entail more work than the station agent can attend to, for if a track layout is adopted that requires an extra man on account of the needless running about which the station agent has to do, the plan is manifestly uneconomical. The second thing to avoid is any arrangement which will tend to make the station a death trap. The curse of most such stations is the presence of a grade crossing beside them, so that cars standing on the siding may hide the approach of a train from people passing along the road. It is not alone the reckless drivers of automobiles who lose their lives at such places, for every once in a while some one familiar with the conditions becomes forgetful of the ever-present danger and pays the penalty. This matter of station track arrangement was first brought up in this journal because of such an accident, where a man thoroughly familiar with the local conditions at a little station stepped from behind a train on a siding directly in front of a passing locomotive. It is for this reason that Mr. Foote's suggestion that a standard track layout should not be rigidly followed, but must be considered as a plan to be fitted into local conditions as closely as the latter permit, is really a basic principle in such designs. And the grade crossing fatalities and injuries indicate how vitally important is the planning of such layouts so that the dangers of these crossings may be minimized. The country road of to-day may be the street of to-morrow, and attention to the danger spot where it crosses track can never be safely relaxed.



Main Dam, Maximum Section.

The Croton Falls Reservoir, Croton Water System, New York.

The Croton Falls Reservoir, about 50 miles from the City of New York, forms one of a series now being completed to increase the public water supply. As the present water storage capacity of the Croton River is inadequate to provide for seasons of protracted drought, special efforts have been made to increase it and safeguard the city during the interval before it will be possible to secure the new supply from the Catskills. The practical completion of the Cross River Dam, described in our columns of May 20, 1905, was a part of this work which was considered of such importance as to be deemed emergency construction and the Croton Falls Reservoir, technically known as Reservoir K, is of similar importance, and its design and the award of its contract have been specially intended to secure its service at the earliest possible moment.

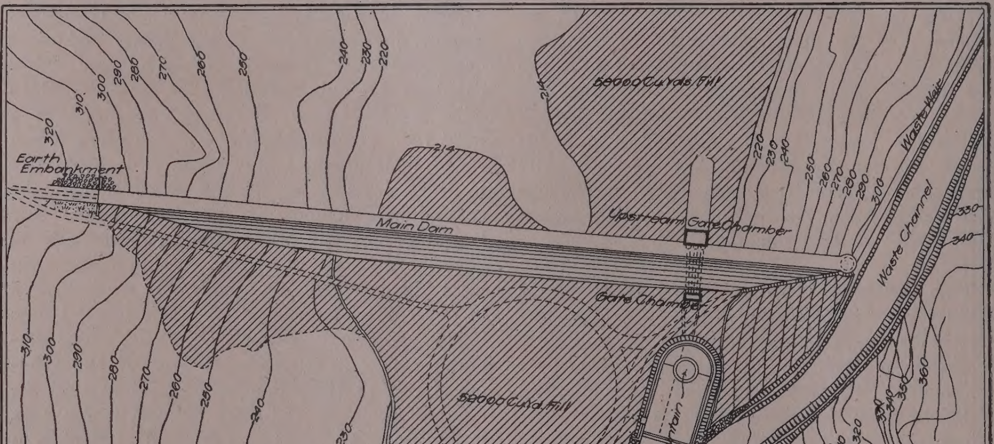
The reservoir will cover a total area of about 1,600 acres and will impound 14,000,000,000 gal. of water with a flow line at elevation 310, about 150 ft. above the inlet of the new Croton Aqueduct which will, indirectly, deliver water from it to the city. The lake, about 4 miles long, will extend north from the main dam built across the west branch of the Croton River at a point in the town of Carmel about a mile north of Croton Falls. The watershed above this site has an area of about 81 square miles with an existing storage capacity of about 17,700,000,000 gal., and the adjacent valley of the east branch of the Croton River about this point has a watershed of over 87 square miles area, with an existing storage capacity of only about 9,600,000,000 gal. In order to impound the flow from the second watershed, a diverting dam is being built across the east branch of the Croton River, about two miles from the main dam, to raise the water to a connecting channel just above this dam, which will deliver to the reservoir of the main dam, about a mile above the latter. The reservoir above the diverting dam follows the approximately straight course of the river and has a regular area about 1,200 ft. in average width and 7,000 ft. in length, but its contents, being below the inlet to the connecting channel, are not available for supply. The main reservoir has an exceedingly irregular outline, following up both the west and middle branches of the Croton Rivers which unite just above the dam and are separated by a comparatively high promontory between them.

The reservoir construction includes the building of both dams and their appurtenances, the connecting channel, the temporary controlling work, the clearing of the site, construction of new highways and bridges, and enclosing the city property by a stone boundary wall.

The Main Dam.—The main dam will cross the valley, approximately at right angles to the river channel, between steep hills and will be founded on solid ledge rock at a probable maximum depth of about 60 ft. below the original surface of the ground. It will be built principally of cyclopean masonry faced with concrete blocks, and the main portion, about 1,070 ft. long on top, will have a height of at least 167 ft., and a maximum width at the base of approximately 125 ft. with a uniform width of 25 ft. between hand rails. The west end of the dam terminates in a core wall which will extend down into the solid rock of the hillside and be enclosed in embankments on the up and down stream sides. The opposite end of the main dam will terminate at its intersection with the waste weir in a circular bastion of cyclopean masonry 35 ft. in diameter and about 12 ft. high above flow line. The upper part of the bastion will contain a circular storage chamber 25 ft. in diameter and 10 ft. in height, roofed by the reinforced concrete floor of the promenade at the level of the roadway which will cross the crest of the dam.

A 36-ft. 4-in. by 23-ft. 5-in. rectangular concrete gate chamber will project from the upstream face of the dam, integral with it and will contain three vertical shafts each of them intersected, at different levels, by three horizontal inlets controlled by gates and stop planks. The 23½x35-ft. downstream gate chamber will have walls about 12 ft. high and will be roofed at the surface of the ground by a flat concrete slab about 100 ft. below the crest of the dam. It will contain the gate valves controlling the three 48-in. cast-iron outlet pipes from the foot of the upstream chamber.

A reinforced concrete conduit about 90 ft. long will connect the outlet in the gate chamber with a semi-circular fountain basin 70 ft. in diameter which will form the upper end of a paved channel 70 ft. wide, from 3 to 6 ft. deep and about 200 ft. long to deliver the waters to the original river channel. At the upper end the conduit will have a horizontal floor 26½ ft. wide with an elliptical arch of 7½ ft. clear rise forming the roof and side walls. This maximum cross section gradually changes at the lower end to an ordinary horseshoe shape 7½ ft. high and 8 ft. wide, which will communicate with the closed fountain chamber 28 ft. in diameter and 7½ ft. in height with symmetrically arranged circular holes in the roof slab, two of which will be 4 ft., two 5 ft. and two 6 ft. in diameter through which the water will rise into the discharge channel. A 2-in. vertical pipe in the center of the basin will provide for a single jet rising many feet above the main discharge which will merely bubble and boil through the large apertures.



Main Dam, Waste Weir and Waste Channel, Croton Falls Reservoir.

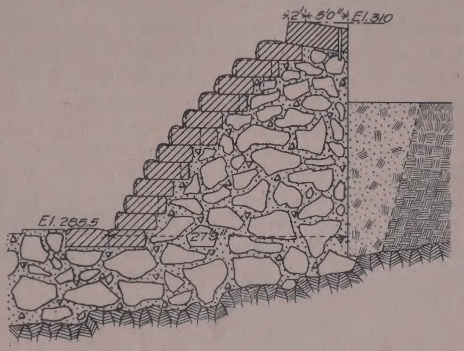
The waste channel, about 1,400 ft. long, will be quarried out of the solid rock in the hillside and pass around the bastion at the end of the dam connecting the reservoir with the waste channel already described. At the upper end it will have a width of 20 ft., and an elevation 5 ft. below the flow line of the reservoir and the width and depth will increase toward the lower end, being respectively 70 ft., and 103 ft. at its intersection with the waste channel. The cross section of the channel varies with the topography and will be made with ¼:1 slopes in the rocks and ½:1 paved slopes at the lower end where the excavation is in earth. In some places the river side of the channel will be made with a heavy concrete wall offset in rectangular steps on the channel side and nearly vertical on the outside. The water will discharge from the reservoir into the waste channel over a weir 1,000 ft. long built on a tangent, with its crest at elevation 310. It will be made of cyclopean masonry faced with blocks of squared granite forming steps of a uniform height of 24 in., the upper one being 6-cut on top and provided with bolts to secure flash boards 2 ft. in height. The height of the water on the weir will be measured by a permanent float valve moving in a perforated vertical pipe contained in a concrete chamber adjacent to the weir upstream. The float will operate an index showing the height on a scale above it.

The cyclopean masonry and concrete will be made from sound rock quarried near the dam site and the stone masonry is made from dimensions stones. The cyclopean masonry is expected to contain about 40 per cent. of large stones carefully packed and set in wet concrete with good vertical and horizontal bonds. The headers and stretchers will be arranged in the same manner as for the Cross River dam as described in The Engineering Record of June 16, 1906, and will be set in cement mortar with joints averaging 1 in. thick and will be built up somewhat in advance of the cyclopean masonry. They will have smooth finished exposed faces and are required to be cast at least three months before being set in the dam. The main dam will contain about 262,000 cu. yd. of cyclopean masonry and 28,200 cu. yd. of cast blocks. The cast face blocks will be each designated by a course letter and every block in the course will be marked with a reference number. Generally every third block in every second course will be a header and all blocks will be cast with a 3x6-in. vertical groove on the center line of each of two opposite end faces, thus providing clearance for the hoisting chain which engages lewis bolts set in the grooves just above the center of gravity of the block. This will enable the chains and lewises to be easily removed after the blocks are set in position in contact with adjacent blocks and the grooves being filled with mortar will form excellent keys bonding the blocks together and insuring water-tight joints between them.

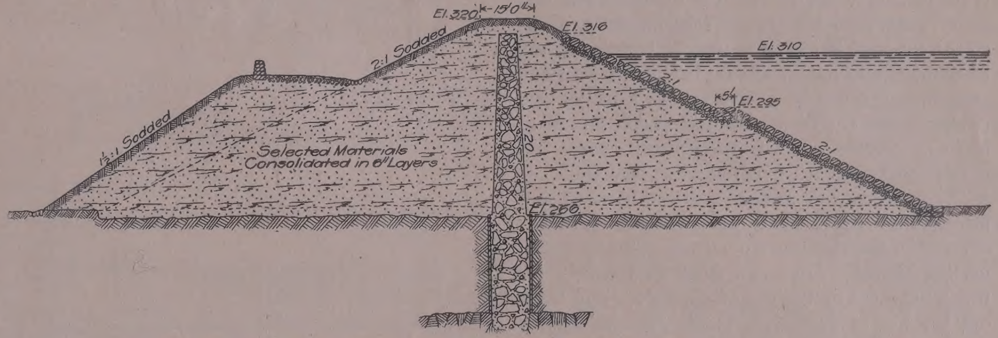
The original channel of the Croton River crosses the axis of the main dam near its south end, and during the construction of the lower part of the latter provision is made for diverting the flow of the river by means of an earth dam across the river about 600 ft. upstream from the main dam. A paved earth channel, 70 ft. wide, 200 ft. long and about 10 ft. deep conducts the flow from above this dam to a curved wooden flume 24 ft. wide, 8 ft. deep and about 500 ft. long which carries it through the west end of the main dam to a paved earth channel connecting with the old bed of the stream just below a second temporary earth dam across its bed about 250 ft. downstream from the axis of the main dam.

The connecting channel between the permanent diverting basin and the reservoir above the main dam will be an open canal 30 ft. wide on the bottom and about 3,700 ft. long, with a uniform grade of 0.2 per cent. From the interpretation of the preliminary exploration it was expected that the excavation would be chiefly in rock to a maximum depth of 60 ft., but so far, it has been entirely in earth. Where the berm is below the maximum flow line there will be, in some cases, a retaining wall built on it, and in other cases the earth slope will be protected by a 24-in. pavement. At the entrance of the connecting channel the water will be discharged from the basin over an overflow weir 6½ ft. wide and 170 ft. long, which will consist of a rectangular concrete sill 3 ft. deep with the upper surface at elevation 305 and the river edge protected by an inclined pavement laid in concrete. The surface of the weir will be continuous with the 6-in. concrete lining on the bottom of the channel.

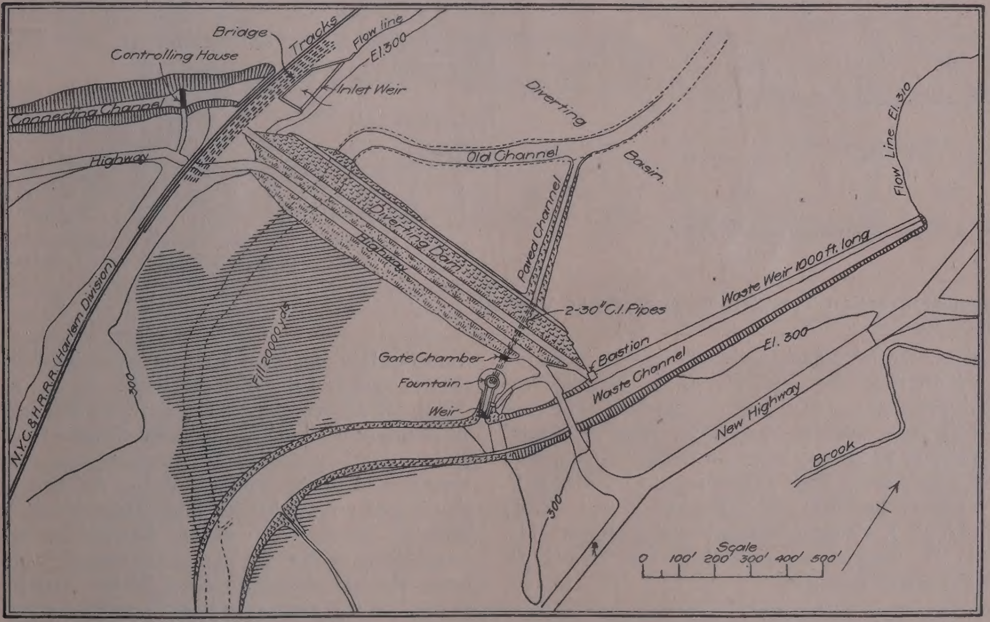
About 100 ft. from the weir, four tracks of the N. Y., C. & H. R. R. R. will be carried across the connecting channel on a skew bridge, and a concrete arch bridge carries the highway across the connecting channel at about the middle point of the latter.



Waste Weir of Diverting Dam.



Cross-Section of Diverting Dam, Croton Falls Reservoir.



Diverting Dam, Waste Weir and Waste Channel, Croton Falls Reservoir.

About 300 ft. below the weir a concrete controlling house will be built across the connecting channel with two vertical walls 12 in. thick and 7½ ft. apart in the clear, transverse to the axis of the channel, supported about 21 ft. above the floor of the channel on seven piers of reinforced concrete about 12 ft. long parallel with the axis of the channel, with clear openings 6 ft. wide between them. The piers will have vertical grooves to receive stop planks which can be operated from the house above to close all or a portion of the channel.

The permanent diverting dam will be about 1,185 ft. long on top with a maximum height of 50 ft. It will be made of earth rolled in slightly inclined 6-in. layers with a 2:1 slope on the upstream face protected by 24-in. paving. The downstream slope will be offset to make a 33½-ft. berm to carry a 23½-ft. roadway, boundary wall and gutter and will have slopes of 2:1 above the roadway and 1½:1 below it, both of them sodded. The dam will have a cyclopean masonry core wall terminating 4 ft. below the crest, at elevation 316. It will have a thickness of 5 ft. at the top, a batter of 1:20, and will extend below the earth fill to a foundation cut in the solid rock, to a probable maximum depth of 30 to 35 ft. below the original surface. At the intersection of the north end of the dam with the waste weir, there will be a cyclopean masonry bastion 25 ft. square and about 20 ft. high with its foundations on solid outcropping rock, which will be provided in the upper part with a storage chamber similar to that in the bastion of the main dam.

A pair of 30-in. cast-iron drain pipes will pass through the base of the dam near the east end and at the upstream end will have a grated inlet to a paved channel about 10 ft. wide at the bottom, 10 ft. in maximum depth and 500 ft. long which will connect with the old river channel. Beyond the downstream face of the dam the pipes will pass through a concrete gate house in which will be located the controlling valve. About 50 ft. beyond the gate house the pipes will discharge through 48-in. vertical expansions into the bottom of a circular concrete fountain basin about 30 ft. in diameter. The overflow from the fountain will pass through an open rectangular concrete conduit, 20 ft. wide, 9 ft. deep and 90 ft. long, to a measuring weir over which it will discharge into the waste channel. The measuring weir will be simply a transverse concrete wall about 4 ft. high with a brass overflow plate at elevation 275. Adjacent to it will be a graduated vertical cast-iron plate for measuring the depth of the water.

The waste weir, about 1,000 ft. long, will make an angle of about 110 deg. with the axis of the dam and will be built of cyclopean masonry with a maximum width of about 28 ft. at the base and a maximum height of 25 ft. above the bed of the waste channel. The outer face will be protected by heavy courses of cut granite offset, as for the main dam weir, to form steps breaking the fall of the overflow water. The coping will consist of large full width blocks of cut granite with the upper surface at elevation 310, from 1 to 3 ft. above the bottom of the reservoir. Unlike the main dam waste weir, it will not be provided with flash boards.

The waste channel will have a bottom width of 21 ft. at the upper end increasing to 66 ft. at the lower end of the weir and to about 80 ft. at the outlet. Opposite the weir where the bottom will not be excavated to rock it will have a very thick lining of cyclopean masonry continuous with that in the weir, and the sides will be protected by heavy concrete retaining walls. Below the dam, where the excavation is in earth, the bottom and sloping sides will be paved 3 ft. thick with large stones very carefully laid.

A temporary earth dam has been built across the old channel about 600 ft. upstream from the permanent dam. The crest of this dam is at elevation 297 and an open flume passing through it and across the axis of the permanent dam will deliver a portion of the water to the waste channel below. The flume 940 ft. long will be somewhat curved in plan and have a uniform cross section 24 ft. wide and 8 ft. deep with transverse sills seated everywhere on the surface of the ground or in cuts.

The earth roads built to replace those which will be submerged have a width of 22 ft., and a wearing surface of gravel or crushed stone on a 6-in. layer of coarse gravel or stone chips. They are protected where necessary by two railed wooden fences 3 ft. high with 6-in. posts 8 ft. apart and four-rail braced gates 10 ft. long. Embankment slopes are usually 1½:1. Blind drains and vitrified pipe drains are provided as required and concrete arch culverts are built where the pipe culverts are inadequate.

All of the city's land will be enclosed by stone boundary walls 4 ft. high above the surface of the ground with foundations at least 12 in. deep. They are 3 ft. thick at the bottom and 1½ ft. thick at the top and are built with roughly dressed stones laid up dry.

The principal quantities involved in the construction of the reservoir include about 632,000 cu. yd. of earth excavation, 251,000 cu. yd. of rock excavation, 20,000 cu. yd. of monolithic concrete masonry, 252,000 cu. yd. of cyclopean masonry, 3,000 cu. yd. of block stone masonry, 28,000 yd. of concrete blocks, 2,700,000 ft. board measure of timber and lumber, 270,000 barrels of Portland cement, 20,000 cu. yd. of dry rubble, masonry and paving, 1,000 cu. yd. of rip-rap, 45,000 lin. ft. of highways, 6,500 sq. yd. of private roads and paths, 100,000 lin. ft. of stone boundary wall.

The contract was awarded on the basis of unit prices, allowing 75 cents per yard for earth excavated in the main and diverting dams and connecting channel, $1.50 and $4.00 respectively for rock excavated by the use of explosives and without the use of explosives in the foundations for the main and diverting dams and connecting channel, $1.75 per barrel for Portland cement, $1.50 per cu. yd. for crushed stone and screened gravel, $8.50 per cu. yd. for concrete blocks, $7.00 per cu. yd. of monolithic concrete masonry, reinforced with steel, and $5.50 when not reinforced, $2.65 per yard for cyclopean masonry and $4.50 per yard for rubble masonry, $55.00 per yard for dimension stone masonry, and $30.00 per yard for block stone masonry, 5 cents per square foot for face dressing concrete, and 50 cents for face dressing dimension stones, $3.25 per yard for rubble paving laid in cement mortar, $2.50 for dry rubble cement and paving and $1.50 for rip-rap; 80 cents for lineal foot for stone boundary wall and $45 per ton for cast-iron pipes delivered and set ready for use.

In order to insure prompt completion of the work and a balanced condition, a schedule of operations was provided which called for the following progress: Three months after award of contract, 6 per cent. of the entire work; 6 months, 20 per cent.; 10 months, 35 per cent.; 18 moths, 72 per cent.; 21 months, 76 per cent.; 27 months, 96 per cent.; 32 months, 100 per cent. This schedule calls for the diversion through flumes of the east and west branches of the Croton River at the main and diverting dams and for the completion of the lower portion of the waste channel of the diverting dam at the expiration of the first three months; for a manufacture of 140,000 cu. yd. of concrete blocks by the end of the first seven months, thus providing for the construction of the main dam masonry up to elevation 225 during the season of 1907; and for the completion by the end of September, 1908, of the main dam to elevation 275, of all the concrete block castings and of the construction of the diverting dam, connecting channels, waste channels and weirs, and a portion of the highways so that the filling of the reservoir may be commenced in the autumn of 1908 between which time and March 1, 1909, the remainder of the contract should be completed.

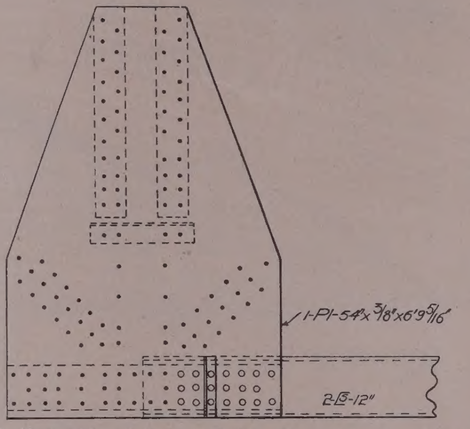
The plans have been made and the work is being executed under the direction of Mr. Walter H. Sears, chief engineer; Mr. Wm. H. Burr, expert engineer; Mr. Geo. A. Taber, assistant engineer; Mr. F. S. Cook, division engineer, and Mr. C. E. Smith, engineer in charge of main dam; Mr. W. Hauck, assistant engineer in charge of diverting dam, and Mr. C. E. Benedict, assistant engineer in charge of highways. The contract was awarded August 23, 1906, at a total price of $3,028,000, based on estimated quantities, to the Croton Falls Construction Co., Mr. J. F. Coogan, president; Mr. Sexton, vice-president; Mr. P. J. Coogan, secretary and treasurer; Mr. P. H. Coogan, superintendent, and Mr. C. H. Forschner, manager.

The Specific Heat of Superheated Steam varies with both pressure and temperature, according to the deductions of Prof. C. C. Thomas, of Cornell University, from an extensive series of tests discussed in a paper presented at the recent meeting of the American Society of Mechanical Engineers. His conclusions are, first, that the specific heat increases when the pressure of the steam increases, and diminishes with an increase in the temperature, and, second, that the specific heat increases and decreases more rapidly when near the saturation point, with increase of pressure and temperature, respectively, than is the case in conditions more remote from the saturation point. These conclusions apply, it is stated, over the whole range covered in the tests, which included pressures from 7 to 500 lb. absolute per square inch, and up to 270° Fahr. superheat for all pressures employed.

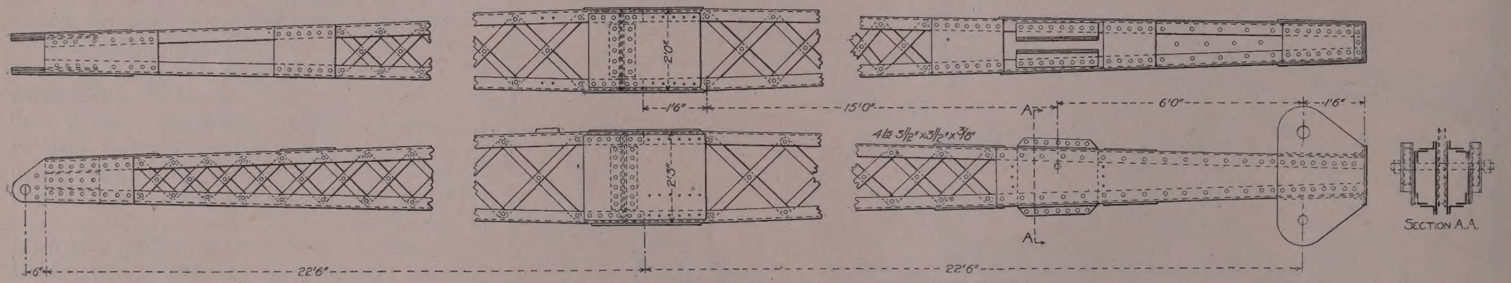
Erection Traveler for the Genesee River Viaduct.

The single-track Genesee River R. R., a branch of the Erie system, crosses the Genesee River on a steel plate girder viaduct 3,121 ft. long and about 120 ft. high, made with alternating 40 and 80-ft. spans and two 120-ft. channel spans, as described in The Engineering Record of Aug. 31, 1907. The vertical tower bents have double-web transverse girders web-connected to the longitudinal girders, except at the skewed river tower, where the longitudinal girders are seated on the top flanges of the transverse girders. The superstructure has been erected by a special overhead traveler resembling that designed by the Erie Railroad Co. for the erection of the Moodna Creek Viaduct and recently described in these columns.

The traveler consists of a pair of rectangular riveted trusses 190 ft. long, 25 ft. deep and 19½ ft. apart on centers, which are connected only by overhead transverse bracing and are designed to move on and overhang the completed structure far enough to permit the erection of two complete panels in advance with material which is carried through and handled from the overhanging trusses. The three forward panels of the traveler trusses ordinarily constitute the cantilever arm 70 ft. long, and there are at their extremity a pair of derrick booms, which suffice to reach to the end of the second panel in advance and handle all of the viaduct members in both panels. The trusses are, however, strong enough so that at the two channel spans of 125 ft. they may be advanced farther than usual and increase the length of the overhang far enough to enable it and the boom to reach a total distance of 165 ft. from the last completed bent and erect both the channel span and the adjacent tower.



Bottom Chord Panel Point, Erection Traveler.



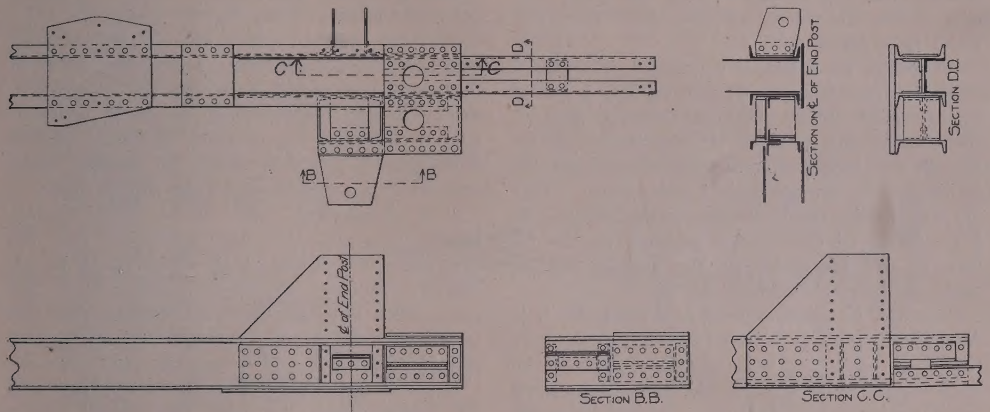
Boom of Erection Traveler, Genesee River Viaduct.

The trusses are of simple construction, with all members made of two pairs of channels back to back, with lattice flanges; gusset plates are shop riveted to the webs of the top and bottom chords and project beyond their flanges to form pairs of jaw plates receiving the field riveted connections of the vertical and diagonal members. Vertical posts L1, L4 and L6 are extended above the top chords and connected by transverse lattice girders extending one panel beyond the trusses on each side, to form with outside vertical bracing attached to the columns a stiff sway bracing very much resembling the end elevation of an ordinary gantry traveler.

At the forward end of the cantilever arm the extended upper ends of the vertical posts serve as masts for the two derrick booms and are connected by an upper transverse strut and one panel of X-bracing. At all other points the tops of the vertical posts are connected in the plane of the top chord with transverse plate girders 18 in. deep, having solid-web kneebraces at both ends and serving to carry the two lines of 20-in. I-beam runways for the trolley hoist, by which the material is carried through the traveler from rear to front. These beams are connected by a transverse strut at the center of each panel, and the main panels between the top chords and transverse struts are X-braced by top lateral angles.

Horizontal cantilever I-beams in the plane of the lower chord carry a light steel framework covered with boards to make a working platform 2½ ft. wide each side of the center line of each bottom chord. This platform is braced by zigzag angles, giving it considerable rigidity and aiding to the lateral stiffness of the traveler.

The transverse bent between vertical posts at the outer end of the cantilever is thoroughly braced by diagonals, sub-diagonals and verticals and is provided with a horizontal transverse outrigger strut 20 ft. long in the plane of the bottom chord. These are braced by diagonal struts to the top chord and are provided with adjustable anchor rods, which can be connected to the feet of the tower posts and increase the lateral stability of the traveler. Just above the top chords a 12-in. horizontal I-beam 30 ft. long is bracketed out from the extension of the vertical post and serves as a sort of jigger beam for the suspension of whip lines and light tackles.



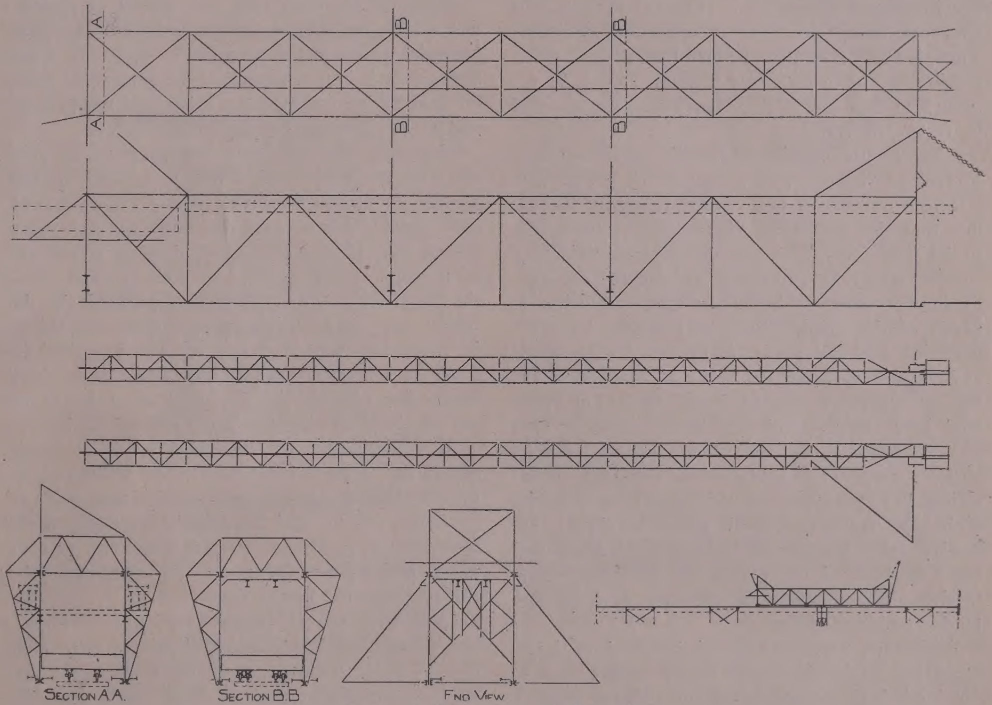
End Bottom Chord Section.

At the rear end of the traveler is a full-width elevated platform about 35 ft. long, built into the trusses to support the hoisting engines, boiler, coal and water supply, etc. On each side of it there is a space outside of the trusses where several 40-ft. girders borrowed from the advance part of the structure can be placed to provide counterweight to balance erection stresses. The upper end of one of the rear vertical posts is extended above the transverse struts to serve as the mast for a stiff-leg derrick having a 20-ft. boom used for handling the hoisting engine, boilers, coal, water and the counterweight girders.

As the viaduct is at first constructed for a single track only, the two lines of longitudinal girders are close together and do not afford a wide enough space for sufficient stability either for the traveler in transit or in service. Provision is therefore made for the lower chords of the traveler to take direct bearing on the top flanges of the double transverse girders of the tower bents when the traveler is in service and is securely anchor bolted to them. As the bottom chords are so far outside of the lines of longitudinal girders, it is impossible to provide the traveler with ordinary trucks in the planes of the trusses for its advance motion, and an arrangement similar to that described in The Engineering Record of Oct. 26, 1907, for the Moodna Creek viaduct has been adopted.

Transverse plate girders 42 in. deep are temporarily connected to the lower ends of the vertical post, L1, L4 and L6; special tracks are run under them, the traveler is jacked up and lowered down to bearing on the trucks and is moved forward by them on four separate lines of rails about 4 and 6 ft. each side of the center line of the viaduct. When the traveler is advanced to the required position it is again jacked up, the trucks released, and it is lowered to bearing on the tower post and the transverse bearing girders disconnected and removed and stored on shore until required for the next movement of the traveler.

There are in all six trucks, each made with two 15-in. I-beams 4 ft. 9½ in. long, with two double-flange wheels tandem between them. Four of these trucks are placed under the beams at L4 and at L6 and two of them at L1, thus reducing the wheel loads to a moderate amount. In order to provide bearings for the traveler on top of the river tower, where the upper flange of the transverse girder is flush with the lower upper flanges of the horizontal girders, two short longitudinal plate girders 121 in. deep and about 16 ft. long are temporarily seated on the top of the tower to receive the traveler. Solid web brackets are bolted to the regular viaduct girders at every second panel point of the viaduct to afford extended bearings for the jacks lifting the traveler off and on the trucks.



General Diagrams of Traveler.

The outriggers at the end of the cantilever arm are made with a pair of 8-in. channels 18 ft. long latticed together and connected to it by a vertical pin through jaw plates extending from the bottom chord flanges. The outer end of the strut is pin-connected to a horizontal diagonal brace made of two angles about 28½ ft. long latticed together and extending back to a pin-connection, with the bottom chord at the next panel point. Near the outer end the outriggers have pin connections for tackles or rods anchoring them to the bases of the towers. The outer ends of the lower chords project a little beyond the panel points to form seats for the steel boom, which revolves in a horizontal plane about vertical pivots.

The booms are each made in several sections, spliced together so that they may be arranged to have a total length of 50 or of 70 ft. They have a rectangular 24 x 27-in. center, cross section made with four 3½ x 3½-in. angles, with the flanges turned in and latticed on all sides, and the end sections are tapered from 24 x 27 in. to about 11 x 11 in. The boom for the rear derrick is made with a 12 x 12-in. stick, and its mast is made with a pair of 5 x 3-in. angles 11 ft. long, latticed and having bolted connections at top to two steel back legs.

As the erection of the Moodna Creek viaduct, 3,200 ft. long and 182 ft. high, was already under way, as described in The Engineering Record of Oct. 26, 1907, and the two other large viaducts over Rock Creek and at Woodbury were under construction, it was decided better not to undertake the erection of all four simultaneously with the erection force at the command of the bridge and building department of the Erie Railroad, and the contract for the erection of the Genessee River viaduct was therefore awarded to the McClintic-Marshall Construction Co., who fabricated the structural steel superstructure and designed and constructed the traveler.

The Erie Railroad construction department is under the charge of Mr. J. H. Graham, vice-president, and Mr. Francis Lee Stuart, chief engineer. Mr. Mason R. Strong, consulting engineer, was the engineer of bridges and buildings at the time that this viaduct was designed.

A GASOLINE SWITCHING LOCOMOTIVE has been built by a Wisconsin firm for handling mining cars and for use on narrow gauge industrial tracks. It is a four-wheel connected locomotive with heavy cast-iron frames and a two-cylinder water-cooled, two-cycle gasoline engine which is designed for self-starting and reversible operation. The engine is arranged longitudinally with a bevel-gear drive to a cross shaft at the rear of the frame carrying the outside cranks for the connecting rods to the driving wheels. The driving gear of the machine follows standard automobile practice in the provision of a slow gear for starting and a friction clutch for the direct drive, which is especially designed with renewable shoes for the friction surfaces.

Notes on Sludge Disposal.

A paper by Geo. W. Fuller, to be published with the report for 1907 of the New Jersey Sewerage Commission.

Visits to sewage disposal works in England and in this country quickly show one striking difference, namely, in this country sewage disposal plants are apt to become more or less neglected with a corresponding diminution in efficiency, while in England this is seldom the case. The cause of this difference is readily found in the character of the management of the disposal works.

While there are numerous disposal plants in this country that have been and are managed with reasonable success, there are comparatively few which would not do better work with such management as is found in many places abroad. In part, this is accounted for by the fact that the majority of the disposal plants in this country are much smaller than scores of plants abroad which have set the pace as to efficiency of maintenance. It is also due, in part, to the lack of appreciation by the local authorities in America of the importance of operating sewage works so as to get a proper degree of purification and without objectionable odors.

The history of water purification plants in America during the past ten years shows a very gratifying increase in the recognition of good operation. Practically all of the larger water filter plants within the last few years have been provided with a laboratory and are operated under intelligent supervision. Careful records and data are taken so as to insure good efficiency. There is every reason to believe that sewage purification works will follow similar footsteps, although at this date it is evident that progress will be rather slower.

After a municipality has made an investment in sewage disposal works capable of giving satisfactory results in every way, it seems incredible that the authorities should allow the works to be neglected, with consequent unsatisfactory results, either as to quality of effluent, the production of odors or both. In fact, the writer is firmly of the opinion that there should be a supervising authority, suitably provided with funds and a technical staff, to see that the plants are not only properly designed and built, but operated in a faithful and intelligent manner. This does not mean that a skilled engineer or a skilled chemist must be employed for constant supervision, but that some one of experience, familiar with local conditions, shall prescribe simple, effective rules for the operation of the plant and the collection of the results of laboratory tests to show just exactly what the plant is doing day by day and week by week.

With such a program carried out, there is no room for doubt that satisfactory results will be obtained, both as to quality of effluent from a properly designed plant and as to freedom from objectionable odors to the neighborhood in which the plant is located.

One of the principal features in the design and also in the operation of sewage disposal works, which deserves attention from the standpoint of both cost of maintenance and the prevention of odors in the immediate neighborhood, is that of sludge disposal. This branch of the plant deals with the treatment of the solid matters suspended in the sewage.

Experience in the treatment of these matters shows that it is difficult to lay down laws or procedures which are capable of universal application with perfectly satisfactory results. There is an individuality to local sewage which must be recognized and properly dealt with. These notes are prepared with a view to emphasizing the importance of good management in general and of due attention to the problem of sludge disposal in particular.

The total suspended matters in sewage usually approximate some ten or twelve grains to the gallon, roughly about 200 parts per million, or something less than one ton per million gallons.

This suspended matter, when applied to intermittent sand filters, is not a serious burden when the beds are new and if the material is porous. Even under these conditions there is formed a scum which requires removal by raking or scraping from time to time in order that air may freely enter the pores of the sand. Ultimately the pores near the surface become sufficiently closed with fats and fine suspended matters removed from the sewage so that the upper portion of the sand layer acts like much finer material than when new.

When the sand bed is composed of material which is fine when new, the surface layer of sand requires more frequent removal than in the case of coarse sand. If not frequently removed, the clogged surface sand would cause the pooling of the sewage applied to the filter. This in turn would result during warm weather in putrefaction of the sewage standing on the filters, as was the case with the original sewage disposal plant at Plainfield, N. J.

In winter clogging of sand is serious, for it is difficult promptly to remove the surface layer or rake it. Consequently before spring comes the sand layers, as they grow old, are apt to show much diminution in efficiency. Where the management is lax there is a strong temptation to bypass the filters.

Filters of stone or slag, like contact or sprinkling filters, are dependent for their efficiency upon bacterial action in the presence of air. In these filters, too, it is necessary that the suspended matter be handled intelligently, otherwise the process will be of questionable efficiency at times.

Obviously it is helpful to keep as much as possible of the suspended solids or sludge in the sewage from reaching the filters, regardless of their type. There may be some special cases where this is not so urgent, but as a general proposition much benefit has been derived from the use of preparatory treatments, particularly the septic tank. With this treatment some two-thirds of the total suspended matters are deposited in tanks under conditions where bacterial agencies cause the removal in the form of a liquid or gas of about one-half of the deposited sludge.

This elimination of suspended solids by septic action has proved very helpful, as witnessed by the fact that at quite a number of places, such as Saratoga, N. Y., and Mansfield, O., septic tanks have been in continuous use for some two to four years without any necessity of removing the sludge deposited in the tanks.

At Birmingham, England, the disposal of sewage sludge has been accomplished for a population of some 900,000 people with strikingly satisfactory results. Several times each year the sludge is removed from the bottom of the septic tanks and applied to land, where it air-dries without any nuisance, although applied to fields adjoining a prominent railroad and within less than one-eighth of a mile of several residences, including that of the manager of the works.

In some cases the wet sludge is applied to land to a depth of 8 to 10 in. and allowed to air-dry without any further attention. In other cases it is plowed into the land after it is dried, to about one-third or one-half of its original depth. In still other cases the wet sludge is applied to deep furrows and then the ridges are turned back with a plow to fill the trenches and cover the sludge.

The secret of success in the disposal of sludge from the septic treatment lies in the removal of the material only after it has undergone bacterial action to a point where there is no further putrescible organic matter for the bacteria to live upon. This shows at once that sludge removal should take place following periods of maximum activity of the bacteria, and not during the winter months when they are at a minimum and when there is present in the septic tanks the greatest percentage of organic matter still undergoing putrefaction. The warmer months of the year are the times for emptying septic tanks for the purpose of cleaning. Then the sludge will contain nothing to putrefy after its removal.

Experiences at Birmingham, England, are perhaps explained in part by the character and age of the sewage when it reaches the septic tanks. The age of the sewage is measured by the time elapsing after it leaves the house connections and before it reaches the disposal works. This requires attention in designing the size of the tanks. It is also quite possible with certain characters of sewage, for a very small sum of money, to add certain chemicals which will artificially produce substantially the same composition of the sewage as obtained at places, such as Birmingham, England, where no trouble whatever has been experienced from sludge odors.

It is certain that septic tanks should be arranged into several compartments, so that the particular tank from which sludge is to be removed will have no sewage applied to it for some little time previous to cleaning. If this is not done there will be some fresh sludge removed which is bound to putrefy after removal.

Experiences at Columbus, O., in working with the sewage from the main city outfall sewer, show results very similar to those obtained in the large plants in England. On the other hand, there are a number of small sewage disposal plants in this country where the sewages from residential districts have behaved quite differently from those of the large cities. This is strikingly true of a number of New Jersey disposal plants.

The sewage from small residential communities usually reaches disposal works in a fairly fresh condition with the suspended matters broken up only to a limited degree and with a considerable portion of coarse particles capable of being removed readily by screens. If the water supply is fairly hard and such as to require the use of much soap, considerable quantities of fats, or what might be called soap suds, appear in the sewage.

Where such a sewage is allowed to go without screening into a septic tank where the depth, arrangement of baffles and general dimensions have not been carefully considered, there is likely to result a difficulty in securing satisfactory bacterial decomposition of the solid matters retained in the tanks. The deposits undergoing rapid bacterial decomposition, with the consequent formation of gas, cause the suspended matters to rise to the surface and form a thick scum. Much of this scum with its entrained gas floats upon the surface and if allowed to remain undisturbed will rise above the sewage level on account of its low specific gravity. Here it seems to dry out and to get beyond the reach of active bacterial decomposition. The result is that there is very little diminution in the amount of sludge due to bacterial activities, and there arises the necessity for removing this suspended matter at far shorter intervals than should be the case. There is also the consequent result that the removed sludge contains much organic matter of a putrefying nature and putrefaction takes place after the sludge has been removed from the tanks.

This state of affairs ought not to exist. The writer is firmly convinced from numerous practical observations that these difficulties are capable of effective control, and that the bother and expense of disposing of undecomposed sludge with consequent risks of troubles from odors can be corrected by following out certain lines of improvements.

Observations at Plainfield, N. J., led the writer to believe for a time that the absence of suitable kinds of bacteria might be a factor in explaining the small amount of sludge decomposed in the septic tanks where there is naturally a very thick scum with but little deposit. However, careful studies along that line lead to the conclusion that the bacteria will do their part if the suspended matters are kept where the bacteria may thrive.

To dispose of sludge from septic tanks without producing odors, the sewage from suburban areas reaching the disposal works in a fresh and practically undecomposed condition, should have attention most carefully directed to the following features:

1. The works should receive faithful attention from intelligent operators who should work under the direction of persons capable of recognizing the individuality of the local sewage in its relation to practical treatment and direct the operations accordingly.

2. The sewage before it enters the septic tank should be passed through screens to remove all the coarser suspended matters, such as have a tendency to float and increase the volume of scum that tends to collect at the surface of the septic tank.

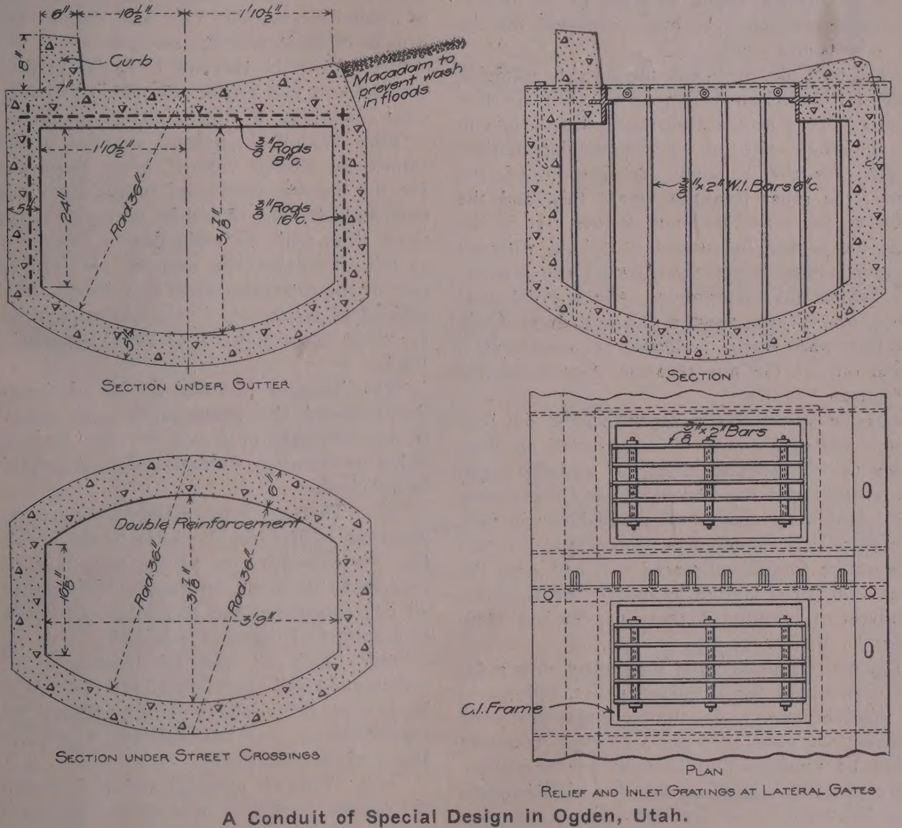
3. The septic tanks should be provided with baffles to keep the scum from reaching the outlet. Where the scum persists in remaining at the surface steps should be taken to subject it to bacterial action. This may be done by manual labor by breaking up the scum and causing it to deposit. It is practical, and cheaper, to effect this by special arrangement of the baffles. Aid may also be derived from flooding the floating scum, after partially emptying the tank, with sewage.

4. The greatest accumulation of solid matter in a septic tank appears near the inlet end and arrangements should be made for keeping this compartment separated from the other portions so that it may be emptied and its contents applied to land or pumped into the other portions of the tank.

5. No sludge should be discharged until it has been freed from putrescrible suspended matter. In this way objectionable odors may be avoided.

Conduit of Special Design in Ogden, Utah.

A reinforced-concrete conduit designed to meet special conditions of a peculiar nature has recently been built in Ogden, Utah. The city occupies a comparatively level site close to the base of a range of high mountains. This site was originally crossed, near what has become the central business district of the city, by a mountain stream carrying considerable flow at certain seasons and always containing some water. After the city had attained some size the irregular course of the stream was straightened so as to confine it to a crosstown street close to the business section. The course of the stream thus remained until the first part of 1906, practically as it was made in the early existence of the city. It was simply an open, unlined excavation in earth, 10 to 12 ft. wide on top and 5 to 6 ft. deep, and with a carrying capacity which varied greatly at different points. The stream also varied from one side to the other of the street, so little of the roadway of the latter was available in places, to say nothing of the unsightly appearance presented by an open water course in a residence street close to the center of the city. At the same time the intersecting streets and sidewalks were also carried over the stream on bridges, resulting in considerable maintenance costs.



SECTION UNDER GUTTER

SECTION

PLAN

RELIEF AND INLET GRATINGS AT LATERAL GATES

SECTION UNDER STREET CROSSINGS

A Conduit of Special Design in Ogden, Utah.

Notwithstanding these undesirable conditions, several circumstances combined to render specially difficult the construction of a covered conduit to carry the flow of the stream. Chief among these was the fact that water has been diverted from the stream for irrigating at various points within the city almost since the latter was started, as the rainfall in the vicinity is light. The water-rights of the lateral irrigating ditches dependent on the stream for a supply are practically sacred, as they are in all intensely irrigated regions, and interference with these rights could not be considered. The laterals are, for the most part, shallow trenches, or pipes laid close to the surface, and were supplied with water from the stream as it existed by simply placing a temporary dam across the channel of the stream to raise the water level in the latter. Consequently, a conduit placed below the ground level could not be built to carry the stream, because the lateral ditches could not be supplied from such a conduit. The principal other difficulty preventing the construction of a conduit laid at any depth was that the elevation of the mouth of the stream in the Weber River, just below the city, and of the portion of the stream which needed improvement most were practically the same, so a suitable outlet could not be obtained.

In order to overcome these adverse conditions the decision was made to build a conduit at one side of the street close enough to the surface to permit the street curb and gutter to form the top of the conduit. This arrangement enabled provisions for supplying the irrigating ditches to be made readily, and also insured a satisfactory outlet for the conduit. On the other hand, it involved what might appear to be serious limitations of design, although none of these proved difficult to overcome. In the first place, provisions had to be made for the extreme variation in temperaure that exists in the summer between the top and the invert and sides of the conduit. The top being directly exposed to the sun, frequently reaches a temperature of 130 to 150 deg. Fahr. during the day, while the sides and invert are constantly kept cool by the water, the temperature of the latter being rarely more than 55 deg. Fahr. At the same time, the conduit had to be built to carry the heavy loads to which it would be subjected directly at street intersections, driveways, and so forth. These unusual conditions were successfully overcome, however, in the design of the section of the conduit built.

The grade at which the conduit was laid varies, so sections of different size, as shown in an accompanying illustration, were used. The invert of the conduit is a semi-circular arch, with a minimum thickness of 5 in. The sides have vertical faces and were built in the excavation, without rear forms, their minimum thickness also being 5 in. The top of the conduit in the normal section has a flat under surface, and over it is the standard street curb and gutter, the section of the curb and gutter forming, in fact, all but a small part of the top. The latter is reinforced with ⅜-in. round rods, which are placed transversely 8 in. apart, 2 in. from the lower face, and extend over the side walls, and the top is also reinforced against temperature stresses by four ¼-in. round rods, placed longitudinally at equal distances apart across it. The side walls contain ⅜-in. rods placed vertically, 16 in. apart, to tie them to the top. At all driveway entrances to private property the amount of reinforcement was doubled, the spacing of the rods being reduced by half, since the loads come directly on the conduit at such points. At all street intersections the top of the conduit was arched, as shown in one of the accompanying sections, and at the center of the intersecting streets it is covered with 8 to 10 in. of earth, this covering being graded down toward the sides of the street by the crown of the latter. Two street railway tracks cross the conduit at one street intersection, but the only provision made to carry the concentrated loads on these tracks was to imbed two pieces of railroad rail transversely in the top of the conduit under each rail of the tracks.

The conduit has been built and in service for one winter and two summers, during which time it has carried all the loads brought on it, including a 16-ton road roller and a 35-ton. traction ditching machine, without any evidence of weakness. Neither have the extreme simultaneous temperature variations in different parts of the conduit caused any difficulties, other than an occasional vertical crack in the curb outside the expansion joints, which joints are placed 15 ft. apart in the curb. These cracks do not extend into the top of the conduit and are to be found with at least as great frequency in curbs of the same cross-section on the opposite side of the same street.

The grade of the conduit follows quite closely the grade of the street, the conduit having a carrying capacity of 50 cu. ft. per second. The velocity of the water in the different-sized sections, used on account of the variation in grade, ranges from 7 to 15 ft. per second. In spite of these high velocities, when the conduit of comparatively small cross-section was substituted for the wide rambling stream some local apprehension was felt as to its capacity for carrying maximum flows in the stream, since the later on one occasion, at least, became obstructed and flooded the adjacent district. The conduit was subjected to an abnormally heavy flood last spring, however, which it carried without being quite filled. Even though such a flood should over-tax it, openings provided at connections to the lateral ditches permit the surplus to overflow into the gutter formed in its top, this gutter at the existing grades having been built with a large carrying capacity.

The connection at each lateral ditch consists of a 90-deg. bend of sewer pipe on the lot side of the conduit, with one end of this bend opening into the latter and the other end connecting with a short vertical section of pipe which ends in the lateral. The water level in the conduit can be raised so water can be diverted into the laterals, as desired, by placing boards against a transverse row of seven ⅜x1½-in. vertical bars set in the conduit just below the connection to each lateral. These bars do not seriously obstruct the conduit, and the boards placed against them can be removed readily. The arrangement also avoids the obstruction a gate would offer in the conduit as well as the difficulties that gates might occasion during a flood. The unsightly appearance of the gates raised above the gutter when not in use and the obstruction to the flow in the gutter offered by the gates in the raised position are likewise avoided.

The bottom ends of the transverse row of vertical bars at each lateral connection are imbedded in the invert of the conduit, and their top ends are supported between two horizontal ⅜ x 1½-in. bars, the ends of the latter being in the sides of the conduit. A 1.5 x 2.35-ft. opening, covered with a grating, is placed in the top of the conduit on each side of the top of the transverse row of vertical bars, in order that access may be had to place against those bars or to remove stop planks used to raise the water into the laterals. These openings are also large enough to permit the water to rise through the upstream one and flow over the horizontal bars into the downstream one, in case debris lodges against the vertical bars sufficiently to block the conduit. Any flow in excess of the capacity of the conduit may also thus leave the latter and continue in the gutter, or a surface flow in the gutter may enter the conduit through the openings.

The conduit was designed by Mr. A. F. Parker, city engineer of Ogden, and was built under his direction. The top of the conduit, being practically the standard curb and gutter used in Ogden, was built at the expense of the abutting property owners, as all such improvements are provided in Ogden. The balance of the conduit was built by the city. The total cost of the 4,300 ft. of conduit was $13,628.62, of which the city paid $8,989.06 and the property owners $4,639.56.

Unusually Thick Floors are used in a jute mill just completed for the Columbian Rope Co., Auburn, N. Y., from the plans of Mr. Charles T. Main, of Boston. They are made of 6-in. plank with ⅞-in. maple top.

A Central American Railway.

A paper by Theodore Paschke presented by the Costa Rican Delegation to the recent Central American Peace Conference.

At every recurring family quarrel taking place regularly within relatively short periods among our Central American friends and neighbors, the question "What is to be done with Central America" presents itself to the average observant, thinking American, and no satisfactory solution of the problem can be found in any utterings of the country's press. To be sure, a Central American Union or Confederation suggests itself immediately, in considering the question, as the only rational remedy to be sought to apply. There is no dispute about the correctness of this; every one admits it, even the Central American, be he a dweller in Guatemala or Costa Rica, in Salvador, Nicaragua or Honduras. Yet, it is safe to assume that the highly patriotic desire to bring about such a confederation has been the secret driving spring of many of the fraternal conflicts which have been witnessed for the last seventy-five years.

Why, then, do the many attempts to establish a Central American Union prove such abortive failures? It is because they have their origin in the ambitious spirit of some particular, limited locality, for the complete domination of the whole; the other localities resent this, and the result is strife and ultimate failure. It is because the proper foundation is lacking whereon a Union edifice may be constructed and rest secure against the undermining influences of local dissensions. This, then, is the first duty of the architect who would undertake to construct a Union out of the five separate commonwealths in Central America.

It is the object of this paper to point out how such a foundation may be constructed on lines which are in keeping with the traditions and avowed policy of the United States Government. There is nothing new in the proposition; in fact, the ground has already been cleared and the outlines of the foundation traced out, and even the excavation for it started by one of the foremost architects of his time in that line, the late Hon. James G. Blaine.

It is entirely proper, and the present time a fitting opportunity for the constructive activity of our administration at Washington, that this work of laying the foundation for a Central American Union be resumed and brought to completion. There can be no question that the establishment of a "Community of Interest" among the five commonwealths of Central America, something which is tangible to the paramount interest of each and every one of them, would offer the best foundation possible for a Union.

It is only necessary to point to the project of an Intercontinental Railway to see how readily in connection therewith such a "Community of Interest" may be established. A line of railways constructed on the location of the Intercontinental Railway project extending from Mexico through Central America, having for its southern terminal the City of Panama, would establish an all-rail communication from the United States to the Panama Canal; certainly a desirable line to have from whatever standpoint it may be contemplated. And if this railway line is controlled by one corporation (American), in the management of which each one of the five Central American commonwealths would have an active interest, it would certainly form a naturally broad and firm foundation on which the Confederation would surely grow up spontaneously and rest securely for all time to come. It would not only establish a community of interest among the Central American Republics, but it would include in this community the United States and Mexico as well.

A practical line and method of procedure for the accomplishment of the object in view is suggested in the several paragraphs following:

First. A company to be organized under the laws of the United States for the purpose of establishing a through rail communication from the southern boundary line of Mexico across the countries of Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and part of Panama to the city of the same name.

Second. The company to recognize and accept as the guiding spirit in shaping its policy the general principles recommended by the Committee on Railway Communications in their report to the International American Conference, and accepted by that body at a meeting held in the city of Washington on Feb. 26, 1890.

These general principles, as far as they represent a living force, are for convenience sake here reproduced as follows:

"1st. That a railroad connecting all or a majority of the nations represented in this conference will contribute greatly to the development of cordial relations between said nations and the growth of their material interests.

"5th. That the railroad, in so far as the common interest will permit, should connect the principal cities lying in the vicinity of its route.

"6th. That if the general direction of the line cannot be altered without great inconvenience, for the purpose mentioned in the preceding article, branch lines should be surveyed to connect those cities with the main line.

"7th. That for the purpose of reducing the cost of the enterprise, existing railways should be utilized as far as practicable and compatible with the route and conditions of the Continental Railroad.

"8th. That in case the results of the survey demonstrated the practicability and advisability of the railroad, proposals for the construction either of the whole line or sections thereof should be solicited.

"9th. That the construction, management and operation of the line should be at the expense of the concessionaires, or of the persons to whom they sublet the work, or transfer their rights with all due formalities, the consent of the respective Governments being first obtained.

"10th. That all materials necessary for the construction and operation of the railroad should be exempt from import duties, subject to such regulations as may be necessary to prevent the abuse of this privilege.

"11th. That all personal and real property of the railroad employed in its construction and operation should be exempt from all taxation, either national, provincial (state), or municipal.

"12th. That the execution of a work of such magnitude deserves to be further encouraged by subsidies, grant of land, or guarantees or a minimum of interest.

"14th. That the railroad should be declared forever neutral for the purpose of securing freedom of traffic.

"15th. That the approval of the surveys, the terms of the proposals, the protection of the concessionaires, the inspection of the road, the legislation affecting it, the neutrality of the road, and the free passage of merchandise in transit, should be (in the event contemplated by article 8th), the subject of special agreement between all the nations interested."

(Articles Nos. 2, 3, 4, 13 and 16 are omitted in the above for the reason that the object to which they refer, i. e., the preliminary surveys, has been carried out and accomplished, which makes them at this date a dead letter.)

Third. The company to acquire control, either by lease or purchase, of all such existing railway lines which will become parts of the main trunk line of the Intercontinental Railway.

Fourth. The company to construct such additional new parts of the proposed railway system as are necessary for the accomplishment of the object in view. The surveys heretofore made under the direction of the Intercontinental Railway Commission to form the basis for future operations in this direction.

Fifth. The Governments of the countries named in paragraph No. 1 to grant the necessary and usual concessions to the railway company, embodying the free right of way through public lands, for the construction of the new parts of the railway through their respective territories.

Sixth. The said governments to give further material aid for the construction of such new lines in the shape of subsidies and grants of land; in return for which the railway company to issue in favor of each corresponding government a proportionate amount of its capital stock, all as may be mutually agreed upon.

Seventh. The Government of the United States to assure the prompt carrying through of the enterprise by guaranteeing a reasonable minimum of interest on the capital invested in the enterprise.

Eighth. Each of the aforesaid governments to have the right to name one representative in the Board of Directors of the Railway Company. Such representative to receive a fixed annual salary to enable them to make their residence within easy access of the place of meeting.

Ninth. The principal office of the Railway Company to be located in the United States at a point in accordance with the requirements of its charter.

A Vice-President of the Railway Company, who shall also be the General Manager, to have offices and residence at some convenient city in Central America, with sub-offices at the seat of government of each of the countries traversed by the railway.

Tenth. The initial steps for the enlistment of the co-operation of all the countries interested in the realization of the project, should be taken jointly by the Government of the United States and that of Mexico.

To show the financial requirements for the realization of the project, the above table, furnishing certain data taken from the Reports of the Intercontinental Railway Commission, is given.

INTERCONTINENTAL RAILWAY—CENTRAL AMERICAN DIVISION.

Location.	Miles Built.	Miles To be Built.	Cost for Grading, Masonry and Bridges.	Average, Cost Per Mile.
Across Guatemala:				
Ayutla to Caballo Blanco	.....	26.2	$324,518	$12,386
Cabello Blanco to Santa Maria	84.1	......	....	....
Santa Maria to Rio Paz	.....	60.5	893,536	14,769
Total	84.1	86.7	$1,228,054	$14,164
Across Salvador:				
Rio Paz to near Acajutla	.....	26.5	$255,196	$9,630
Near Acajutla to San Salvador	64.0	......	....	....
San Salvador to San Vincente	.....	42.2	1,157,433	51,124
San Vincente to San Miguel	.....	62.0	793,104	12,792
San Miguel to Rio Guascoran	.....	36.1	781,901	21,659
Total	64.0	166.8	$3,987,634	$23,907
Across Honduras:				
Rio Guascoran to Rio Negro	.....	71.7	1,108,697	$15,463
Across Nicaragua:				
Rio Negro to Chinandega	.....	38.0	$598,960	$15,762
Chinandega to Granada	103.4	......	....	....
Granada to Peña Blanca	.....	68.3	907,390	13,285
Total	103.4	106.3	$1,506,350	$14,170
Across Costa Rica:				
Peña Blanca to Liberia	.....	52.5	$1,167,430	$22,237
Liberia to Boca Savegre	.....	157.5	3,820,000	24,254
Boca Savegre to Rio Golfito	.....	150.0	3,353,487	22,356
Total	.....	360.0	$8,340,917	$23,169
Across part of Panama:				
Rio Golfito to David	.....	59.6	$955,353	$16,029
David to City of Panama	.....	274.4	4,657,280	17,009
Total	.....	334.0	$5,612,633	$16,804
	251.5	1,125.5	$20,784,285	$18,467

By deductions from the data in the table the salient features of the project will appear as follows:

Total length of railway line from the southern boundary of Mexico to the City of Panama will be 1,377 miles, of which 251.5 have been built and 1,125.5 are to be built.

The cost of the new construction of the railway line is estimated by the Commission's engineers for grading, masonry and bridges, at $18,467 per mile. This figure should be augmented by about 12½ per cent. to cover contingent, engineering and administrative expenses, which would bring the average cost in round numbers to $21,000 per mile.

Adding for cost of superstructure, full equipment, and rolling stock the sum of $19,000 per mile, we get the entire cost of the new construction to be $40,000 per mile.

The total cost of the project will then be as follows:

1,125.5 miles new construction at $40,000..	$45,020,000.00
130 miles of sidings at $20,000...........	2,600,000.00
Widening the gauge of present constructed lines to standard gauge, 251.5 miles at $10,000	2,515,000.00
Total cost of main line.............	$50,135,000.00

In addition, two branch lines should have to be constructed, one in Honduras to connect with the capital, Comayagua, length 75 miles, and the other in Costa Rica to connect with the existing railway line at Alajuela, which connects with the capital, San Jose, the length of which will be about 25 miles, making in the aggregate 100 miles more. (As regards Costa Rica, it is to be observed that the construction of the railroad from San Jose, the capital, to Puntarenas, on the Pacific Coast, is now almost finished, and that in a few months traffic will be opened thereat, thus completing the Costa Rican Interoceanic Railway between said port of Puntarenas and Port Limon, on the Caribbean Sea.) The construction of these branch lines would have to be estimated at an average cost of $65,000 per mile, owing to the more difficult character of the country encountered in ascending the slopes of the mountain plateaus on which these cities are located. This will swell the total amount of capital required, in round numbers, to $56,000,000.

The Pacific slope of Central America embraces within its confines some of the best and richest agricultural lands of the continent north of the Isthmus of Panama. It is here where most of the coffee, sugar-cane and cocoa plantations of the Central American countries are located; where these products are grown to the greatest perfection. It is here where the fountain of all wealth of these countries is located. This "Coffee Zone," as it is generally known, occupies the Pacific slope of Cordilleras between elevations of 1,000 to 5,000 feet above sea level. It reaches its greatest width and unbroken continuity through the western part of Guatemala, where the belt is about 70 miles wide, extending well into the Mexican State of Chiapas. Through the eastern part of Guatemala, Salvador, Honduras, Nicaragua and Costa Rica, the belt, which diminishes and varies in width, is less continuous, somewhat broken by outrunners from the Cordilleras, which show more of an arid character; however, its many valleys possess all the richness of soil and climate of the "Costa Cuca" in western Guatemala. It is through this Zone or rather at the foot of which the proposed railway line has been located by the Intercontinental Railway Commission. With the intercommunication which this line would afford throughout the length of this Zone, there is sufficient traffic in sight from local sources (short haul freight and passengers) to sustain the life of the railway with decided healthful vigor from the very start, leaving alone any through traffic which will surely more or less develop from the United States and Mexico to the Canal Zone. The further development of the great natural resources, not only of the "Coffee Zone," but of the whole Central American territory, which will surely follow the opening of this line, will insure its prosperity in the near future beyond adventure. More, the Intercontinental Railway of Central America will be the key to unlock the gates of the hidden treasure house, which nature has so lavishly provided with the products of a most favored zone.

In conclusion, the writer would touch upon another feature, inherent to the project and capable of being developed into an exceedingly strong characteristic of the undertaking. It is this: The line of the projected railway lies along the foot of the Pacific slope of the Central American Cordilleras. In its course it traverses numerous streams which are fed from the high plateaus of the Cordilleras. The more important of these streams which are crossed at short intervals will furnish an abundance of electric power, not only sufficient to operate all railroads existing and to come, but to furnish light and power for every conceivable and needful purpose in these countries.

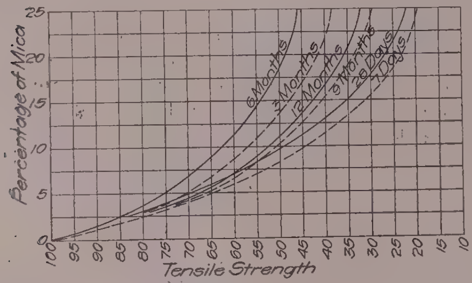
From the moment that a company composed of the right elements for the purpose in view is organized and negotiations begun, all fraternal strife between the five Central American Republics would cease, their attentions would be directed by their larger sisters of the north to a rising dawn, promising to shed its golden light in common over all. During the construction of the road their surplus energy would be attracted and employed in a work of common interest to all. At the conclusion of the work and the opening of the road there will be general manifestations of congratulations and good cheer and good will towards each other. Once the railway line as a whole is in active operation, the practical unification would thereby become an accomplished fact.

Our own interest at Panama, in opening new and extending old trade channels in the existence of peaceful and stable conditions in Central America, combined with our duty towards common humanity, demands that the construction of this first section of the Intercontinental Railway be taken in hand at once. The present time seems opportune indeed for the initial move for the accomplishment of the project; its realization would certainly write another chapter in the history of practical achievements towards the goal of Pan-Americanism.

Mathematics for Engineering Students.

One of the engineers who contributed views on mathematical studies for engineering students at the recent meeting of the American Association for the Advancement of Science was Mr. Ralph Modjeski, who is particularly well qualified to speak on the subject. As a student at the famous Ecole des Ponts et Chaussees at Paris he followed a more comprehensive mathematical course than is given in any American technical college to-day, while his practice as a bridge engineer has made it necessary for him to use mathematics to a far greater extent than is required in other branches of civil engineering. His discussion of the subject is given below:

Mathematics is to an engineer what anatomy is to a surgeon, what chemistry is to an apothecary, what the drill is to an army officer. It is indispensable. I think we all agree on this point. The questions before this meeting are, how much mathematics should be taught to the engineering student, and how to teach them. There is considerable agitation at this time in France and Germany, especially the former, favoring the limitation of the present mathematical program of the engineering schools on the ground that it is unnecessarily extensive. From personal observation I can say that the program there covers a considerably wider range than in the average American college. In the first place, a student entering an engineering college on the European continent must already know analytical geometry, descriptive geometry and the rudiments of differential and integral calculus, none of which is generally taught here until the student enters college. The average length of a college engineering course abroad is four years, one of the exceptions being the Ecole Centrale of Paris, France, where the course is only three years, but where the entering examinations are of a comparatively high standard and the students must be above the average in ability and application in order to hold their own during the college course. It is obvious, therefore, that in the American college time is spent on abstract mathematics which should be devoted to practical study. This is probably to the detriment of applied mathematics. I believe the time will come when only applied mathematics will be taught in colleges and all necessary pure mathematics will form a part of the conditions for entering.



Percentage Decrease in Tensile Strength with Increase of Mica.

As time goes on, every profession tends more and more towards specialization. This tendency is quite marked in the engineering profession. It would take too long to enumerate all of these special branches of engineering, but nearly every branch demands a somewhat different mathematical training. Time may come when this specialization will extend over the study of abstract mathematics, differing with each student according to the branch of engineering he intends to follow. For instance, a railroad engineer who may aspire to become a railroad official requires less knowledge of calculus than an electrical or bridge engineer. On the other hand, he requires a greater knowledge of geology than the electrical engineer, and a greater knowledge of common law than the bridge engineer. As my remarks are merely intended to furnish fuel for discussion I will put the following question: In view of the steadily growing scope of special education, will it be desirable and possible to specialize mathematical courses in colleges and adapt them to each branch of engineering? This, I understand, is done at present only to a small extent in applied mathematics.

Bridge engineering, of which I have made a specialty, requires probably as high a mathematical training as any other branch of the profession, and yet I find that part of the abstract mathematics which I have studied in college, apart from the drilling feature of such studies, has been entirely useless; for instance, the theory of differential equations. The time I spent on it, though considerable, was not sufficient to make me understand it thoroughly, and would have been better employed on the study of the methods of least work, for instance, which no bridge engineer should neglect to study.

On perusing the elementary text books used in high schools, I have been often struck with the dry, uninteresting manner in which the various subjects are treated. The examples are mostly abstract; very few practical problems to work out. Unless the student is very diligent, his mind retains nothing beyond a chaos of formulae hard to remember and a few mechanical means of solving abstract problems. He is incapable of applying an equation to a practical problem. The methods of presentation should, therefore, be such that the student knows the why and wherefore of each operation; in other words, that he learns to think mathematically. This should also be the chief aim; to be able to "think mathematically." One does not know a foreign language unless one can think in that language. One does not know mathematics unless one can think mathematically. It is not necessary for this to go up into highest mathematics, but it is necessary to be thoroughly drilled in elementary principles of each subject. These elementary principles should become a second nature to the student, just as a language becomes a second nature when it is thoroughly acquired. Problems arise every day in the practice of an engineer which a mathematical mind can solve without going into calculations; the principles of maxima and minima, those of least work and others are invaluable in assisting to arrive at a logical solution of many problems without the use of paper and pencil; but in order that they may be applied, one has to be able to think mathematically. With a proper foundation, the engineer's mind becomes so trained that he applies those fundamental principles unconsciously. How to secure such a foundation in a student must be left to those who make a life study of teaching.

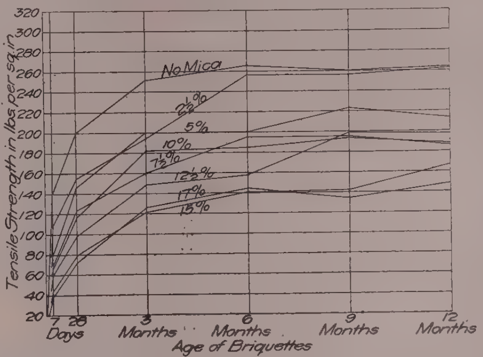
The Pennsylvania Terminal in New York has required 1¼ miles of heavy concrete retaining walls.

Does Mica Weaken Concrete?

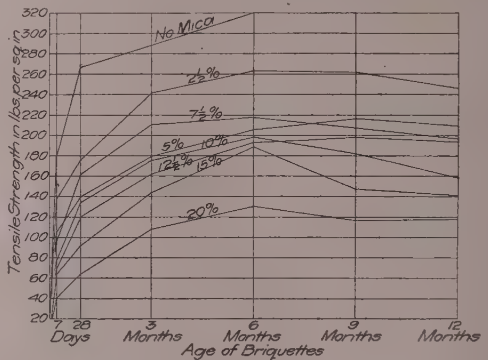
By W. N. Willis, Cement Tester, South & Western R. R.

The accompanying charts give the results of tests made in this laboratory showing the decrease in the strength of mortar or concrete when the sand contains an appreciable amount of finely powdered mica. In many parts of the country, especially in sections of North and South Carolina, Tennessee, Virginia and Pennsylvania, the sands contain so much mica as to be worthless for concrete, the coarser sands containing from 3 to 4 per cent. and the finer sands, which at best are poor for concrete work, containing from 10 to 15 per cent The waters, in grading the sands, to a certain extent separate the mica from the sand, leaving but a small percentage of mica in the coarser sands which are first deposited, but depositing the greater part with the fine sand.

Sand containing mica shows quite an increase in voids, as well as decrease in strength; the Ottawa sand used in these tests, loosely shaken, contains 37 per cent. voids, but increases gradually until the sand which contains 20 per cent. of mica has 67 per cent. of voids, and at the same time shows a decrease of 20 per cent. in weight. The increase in voids alone will decrease the value of the sand for concrete, while the surfaces of the mica are slick and do not make a good bond with the surrounding cement. As a general thing, the heavier a sand the better it is fitted for concrete, grading being the same. Sand which contains 20 per cent. mica requires three times the amount of water for mixing as the same sand without mica.



Effect of Mica on 1:3 Mortar of Pittsburg Crushed Quartz.



Effect of Mica on 1:3 Mortar of Standard Ottawa Sand.

The mica used in these tests ranged from 2.45 to 2.60 per cent., averaging 2.55 per cent., and was ground until all passed a No. 10 standard sieve, 29 per cent a No. 20 sieve, 10 per cent a No. 50 sieve and 4.5 per cent. a No. 100 sieve, making it as near as possible like the mica in the natural sand.

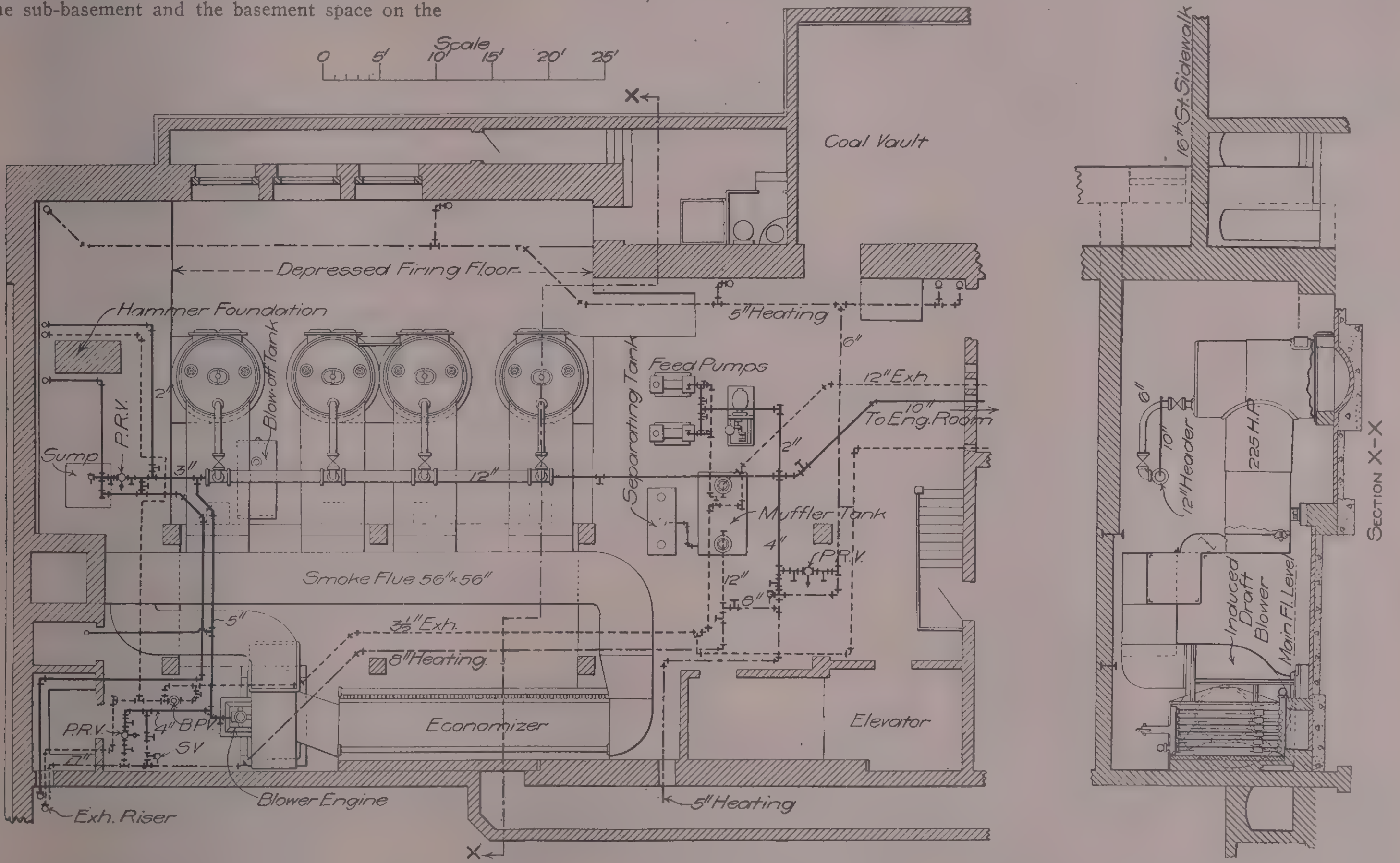
The first chart, with Ottawa sand, was made from four sets of tests, made in two parallel series about six months apart, and the averages taken, while the second chart, with crushed quartz, was made from one set of tests, two and three briquettes being broken at a time, not enough to equalize the faults from imperfect mixing, etc. The curves show graphically the decrease at each period of time.

All mixtures were made of one part cement to three parts sand, or sand and mica, the mica being in percentage of sand; all by weight.

A Power Contract with an unusual penalty for failure of supply, has been made by the City of New York with the New York Edison Co., for the operation of the electric pumps for the new emergency high-pressure fire mains, described recently in this journal. A penalty of $500 per minute is imposed for failure of the electric power supply within three minutes after a fire alarm.

Mechanical Plant of the Stuyvesant High School, New York—Part I.

The Stuyvesant High School is a new building on East 15th and East 16th Sts., New York, for day and evening instruction in manual training. It is located between Second and First Aves. and occupies a 206x210-ft. plot of ground. It is a five-story building with basement covering the entire plot and a sub-basement 32 x 44 ft. in size under one side of the 15th St. front. Above the first floor there are light and ventilation courts of irregular shape on the middle of either side, which provide ample exterior window area for all rooms. The building is devoted to class-rooms, lecture rooms, laboratories and offices above the first floor, the first floor and basement being devoted principally to a 90x100-ft. auditorium and a 92x100-ft. gymnasium, both of which are lighted by sky-lighting from the light courts above. The mechanical equipment is in the sub-basement and the basement space on the 16th St. side, occupying practically the entire space across that front of the building, 40 ft. in width.



Plan and Section of Boiler Room of Stuyvesant High School.

The mechanical plant of the building comprises a power plant of 900 boiler h-p. capacity for general heating and power purposes, a 550-kilowatt electrical generating equipment for lighting and power transmission, and an extensive ventilating equipment for ventilation throughout practically all of the building. It was the original plan to install only a boiler plant for steam heating and ventilating purposes, but after a study of the electrical requirements of the building for lighting and power service, and furthermore the desirability for a modern power plant equipment for demonstration purposes in connection with the manual training instruction, it was decided to add the electrical generating equipment to the plant, as a result of which a boiler capacity of 900 h.-p. was selected in preference to an original figure of 600 h.-p. The types of equipment selected are in some cases of interest, as influenced by local conditions. With the smaller boiler capacity of 600 h.-p. as would have been required for heating purposes only, it had been planned to make use of boilers of the horizontal return tubular type, but with the increase in capacity to 900 h.-p. of boilers as required by the electrical generating equipment, it was found impossible to install sufficient capacity in boilers of the return tubular or water-tube types in the space that had been alloted for this purpose. Accordingly the Fitzgibbons boiler was chosen as the type most suitable for the purpose owing to relatively small floor space and head room occupied for a given capacity, it having been found that four boiler units of this make, of 225-h.-p. capacity each, could be amply accommodated in the 37x46-ft. boiler space that had originally been allowed for in the design of the building. Similarly with the original plans for 600 boiler h.-p. the power plant chimney which was incorporated in the building construction, was incapable of ready increase in size and an induced draft equipment was thus added to permit of operating the chimney at a rate 50 per cent. greater than its natural capacity, advantage being at the same time taken, of the opportunity to install an economizer in connection with the induced draft equipment. Furthermore both classes of electrical generating equipment, direct current and alternating, were installed in the plant for the reason that alternating current was found preferable to direct current for general lighting and power distribution, owing principally to a large use of electric power in small units for which the induction motor is particularly desirable, yet also a considerable use of variable speed motors for machine tool and elevator drives, rendered the supply of direct current, to a limited extent at least, almost imperative.

The boilers are of the usual construction of the Fitzgibbons Boiler Co., Oswego, N. Y., consisting each of 87-in. vertical shells 11 ft. in height over all, which contain the fire box elements, and horizontal shells containing the tube surface which extends in the rear to a total length of 19½ ft. They are conveniently arranged in the boiler room with one at either side and the other two at the centre, the arrangement selected allowing thus two convenient passages 30 in. in width between the units, a 12-ft. firing floor in front of the boilers and an 18-ft. space at the rear. The firing floor and the spaces between the boilers is depressed as far as the rear of the settings, 3 ft. 2 in. below the normal basement floor level. The boilers are designed for 125-lb. working pressure, and each unit contains one hundred and eighty-six 3-in. tubes, 14½ ft. in length. Each unit has a 6-in. steam outlet and two 4-in. safety valve nozzles on the top, and in addition to a 2-in. blow-off connection at the base of the vertical shell, a 1½-in. surface blow-off connection on the side at the crown sheet level, the latter terminating in an oval funnel of the usual type for surface blow. The boiler furnaces are fitted with plain dumping grates having ⅜-in. air spaces, and smoke is removed by a smoke breeching 56 in. square elevated above the boilers at the rear, with 22x63-in. branches to each unit. Fuel is stored in a 30x75-ft. space underneath the 16th St. sidewalk into which the coal is dumped through sidewalk coal holes along the curb, and it has a capacity for about 500 tons. The ashes are removed by a small sidewalk elevator adjoining the boiler room, rising to the 16th St. sidewalk.

The induced draft equipment consists of a 7-ft. full-housed steel plate exhauster of the centrifugal type which is located in the rear corner of the boiler room and direct-connected to a 10x10-in. vertical center crank slide valve engine, which is under control of a Foster fan engine regulating valve for control of the speed of the fan from the boiler steam pressure. The fan wheel is 7 ft. in diameter by 46 in. in width and when operated at 210 r.p.m. has a capacity of 36,000 cu. ft. of gas per minute, this capacity being chosen on the assumption of the necessity of removing 600 cu. ft. of the gas at a temperature of about 500° Fahr. per pound of coal consumed in the furnaces and of a coal consumption of 4 lb. per horse-power hour. The economizer through which the fan draws the gases contains 240 cast-iron pipes, 4 9/16 in. in diameter and 9 ft. long, which are set in 40 sections of 6 pipes each and contain a total of 2,880 sq. ft. of heating surface. The economizer is fitted with the usual scraper gear which is operated from the fan-driving engine and has a 2½-in. safety valve for relief from excessive water pressure and a 3-in. blow-off connection for cleaning. The economizer setting is connected at the end away from the chimney through a dampered cross connection with the boiler breeching, and at the opposite end with the induced draft fan intake, the delivery from the latter joining the main boiler breeching at a point near the chimney inlet. The breeching and flue connections are provided with tight-closing dampers, and a damper regulator in the stack connection, which permit the economizer to be cut out if desired and the furnaces operated with natural chimney draft, this being possible and to be preferred when the plant can be operated with less than four boilers. The economizer equipment and induced draft fans were supplied by the B. F. Sturtevant Co.

The boiler room auxiliaries consist of the usual equipment of a feed water heater, boiler feed pumps, a blow-off system and tank, and a sump tank. The feed water heater is a Ferguson combination muffler tank, oil separator and purifier and return tank, through which the exhaust steam from the engine and pumps is passed for purification before entering the heating system and into which all clean condensation returns from the plant and also make-up water from the city water system for boiler feed are delivered. Incorporated with this tank there is a float valve which governs the feed pumps, of which there are two steam pumps and one of the triplex electrically driven type. The pumps consist of a 7½x5x6-in. Worthington duplex steam pump, a 10x6x14-in. Reilly simplex steam pump, and a 5x8-in. Goulds single acting triplex pump which is direct-connected to a 12-h.-p. General Electric direct-current motor operating at variable speed from 400 to 1200 r.p.m. The muffler tank control of the steam pumps is operated through a balance valve in the steam line supplying them and the pump governor float also operates a switch in the controller circuit of the motor driving the triplex pumps so that the feed pump action is regulated automatically in all cases. The pumps are all so connected that they may draw either from the muffler tank or direct from the city water mains and deliver through a simple system of feed piping over the boilers with a 2-in. branch to each unit. The feed main is looped to ordinarily pass all water through the economizer, but is by-passed for cutting out the latter if desired. As an auxiliary to the feed pumps there is a 2-in. Gresham automatic injector located on the boiler nearest the feed pumps which is connected to draw from the city water mains and delivers to the feed line at a point beyond the economizer connection.

The blow-off system consists of a 2-in. connection from the rear of the base of the vertical shell of each boiler unit and also a 1½-in. surface blow-off connection for each boiler, both connected into a 3-in. blow-off header underneath the boilers at the rear which delivers into a 3½x7-ft. steel blow-off tank containing a cooling coil for reducing the temperature of the blow-off before wasting to the sewer. The cooling coil consists of 23 U-shaped bends of 1⅝-in. brass tubing containing a total of 118 sq. ft., through which the house returns are passed before entering the muffler tank. The blow-off tank receives in addition to the boiler blow-off discharge, the oily drips from the economizer engine and feed pump cylinders, the economizer drain and the relief from the feed water heater and cooling coil connection. The tank has a 2-in. vapor outlet which connects into the nearest atmospheric exhaust riser from the power plant at a point above the back pressure valve. The sump tank, a steel tank, 4 ft. square and 4½ ft. deep, is located in a pit at the rear of the boiler room and receives the drainage from the boiler room pit and blow-off tank which drainage is discharged to the sewer by a 3-in. centrifugal pump located at the bottom of the tank and driven by direct-connected vertical 2-h.-p. alternating current motor placed on a steel frame above the tank.

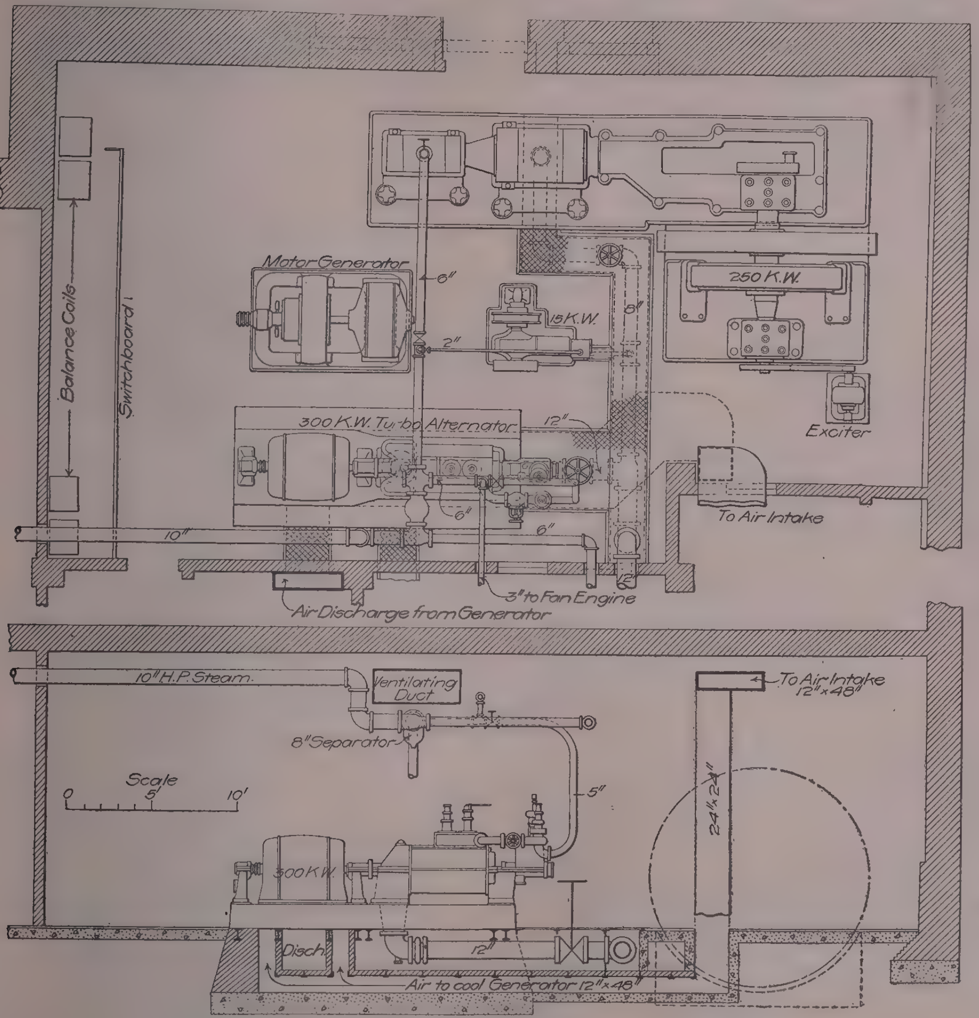
The high pressure steam piping starts with a 12-in. boiler room header located over the boilers at the rear with a runout connection to each boiler through a 6-in. branch fitted with both a gate valve and a Foster non-return stop valve, the latter being fitted for distant operation from a pilot valve permitting quick closure of the valve in emergency. From this 12-in. header a 5-in. connection extends from the rear end to supply pressure reducing valve for low-pressure supplementary supply to a section of the heating system and also for the fan engine supply, and from the opposite end of the header a 10-in. line runs to supply auxiliary equipment in the boiler room and thence to the engine room for the electrical generating machinery and other sections of heating system. From this engine room extension there are 6-in. connections extended through a common 8-in. steam separator to a 375-h.-p. tandem-compound engine and a 300-kw. steam turbine, with from the former a 2½-in. branch to a small steam-driven exciter unit. The main terminates in a third 6-in. connection to pressure reducing valves distributed in that side of the building for live steam supplemental supply to different divisions of the heating mains. Owing to the special equipment of the building for instruction in physics, chemistry and manual training, reduced high pressure steam lines are run to a number of different points on the upper floors to supply glue heaters in the wood-working department, the water still and also a number of vapor baths in the chemical laboratories.

For exhaust steam there is a main exhaust line in the basement division of the plant on the 15th St. side and a small auxiliary line in the sub-basement division of the building on the 15th St. side. The main exhaust line starts with a 12-in. line serving the tandem compound and exciter engines and the steam turbine in common, passing thence into the blower room where connection is made to a blower engine and then across the basement to the boiler room for connection to the grease extractor and muffler tank, with branch to the boiler feed and house pumps and the economizer fan engine. This line which serves as the basis of low-pressure steam heating supply has two back-pressure valves for relief to the atmosphere in case of excess pressure, one of which is a 12-in. Kieley valve connecting to the line near the turbine exhaust which leads to a 12-in. atmospheric riser in the easterly wall of the building nearby, while the other is a 3½-in. valve of similar make and is located in the 3½-in. extension of the exhaust line in the boiler room to the pump and induced draft fan engine. Steam is delivered from these lines to the heating system, however, only through the muffler tank and oil separator, connection being made from the latter to a 12-in. heating main for general distribution. The auxiliary exhaust system is a 6-in. line which serves merely a fan-driving engine and a steam vacuum pump which are located in the sub-basement on the 15th St. side and thus are isolated somewhat from the remainder of the mechanical plant. This system is not connected with the main exhaust system in any way, but has a separate atmospheric exhaust outlet and an independent heating connection to a group of heating mains and stacks that are used in connection with the blower there located. This latter heating connection is made through a 6-in. Kieley combination grease extractor and muffler tank for the purpose of freeing the condensation returns from lubricating oil and relief is afforded this auxiliary line by a 6-in. Kieley back-pressure valve that connects into an atmospheric exhaust riser in the adjoining east wall of the building. This arrangement of apparatus is special in that when the blower is operated for the auditorium the exhaust from the blower driving engine and from the steam vacuum pump will be practically always used in the heating stacks and that when ventilation in that side of the building is not required, the auxiliary exhaust system may be shut down by the operation of the duplicate of the steam-driven vacuum pump which is electrically driven.

The power equipment of the plant consists, as above stated, of a 250-kw. engine-driven generating unit and a 300-kw. turbo-generator with also an engine-driven exciter unit of 15-kw. capacity, and a belt-driven exciter unit of 15-kw. capacity. These units are located in a 30x50-ft. engine room in the easterly front corner of the basement space. The 250-kw. unit which consists of a Ball & Wood tandem compound four-valve engine direct connected to a Westinghouse engine type alternator, is located on a massive foundation at the front side of the engine room, while the 300-kw. unit, a Westinghouse-Parsons turbo-alternator is located at the rear side on a suitable foundation. One exciter unit which is a McEwen engine direct connected to a Thompson-Ryan generator, is located, together with a 150-h.-p. Westinghouse motor generator set, between the two main generating units. The Ball & Wood engine has 15 and 24-in. cylinders with 20-in. stroke and is designed to operate at 200 r.p.m., at which, with an admission pressure of 115 lb. and exhaust at atmosphere, it is capable of a maximum load of 470 indicated horse-power. It has a 13-ft. flywheel and is governed by a balanced centrifugal inverted governor, there being separate eccentrics for admission and exhaust. The turbine is of the horizontal multi-expansion type, especially designed for operating non-condensing and runs at 3,600 r.p.m., and at that speed with 115-lb. admission pressure, it has a normal rating of 450 brake horse-power with an overload capacity of 50 per cent. The exciter engine is a 7x7-in. McEwen simple engine developing at 350 r.p.m., 25 indicated horse-power and governed with a flywheel governor of the Begtrup inverted type. The Ball & Wood engine is provided with a Monarch engine stop aranged to be operated from two convenient points.

The two main alternators are designed to generate 2-phase alternating current at 220 volts and a frequency of 60 cycles, the turbo-alternator, which operates at 3600 r.p.m., having only two poles, while the generator engine operates at 200 r.p.m., and has accordingly 36 poles. Both generators are of the revolving field type and are separately excited from the exciter panel of switchboard. The engine-driven generator has a 15-kw. direct-current exciter unit, connected thereto and driven at 800 r.p.m. by a Renold silent chain drive from the main alternator shaft. The direct-connected engine-driven exciter is a Thompson-Ryan multipolar direct-current unit of similar capacity which is direct-connected to the McEwen engine. Both exciters are wound for 115 volts and are compound wound and especially designed for close voltage regulation. In addition to the above electrical equipment there is installed a motor generator set of 150-h.-p. capacity which is used for transformation of the alternating current power into direct current for supply of direct current to the laboratories, to the elevator motors and to the variable speed motors which are operated in the building. The set consists of a 150-h.-p., 2-phase, 12-pole Westinghouse alternating-current motor which is mounted on the same base with the 100-kw. generator driven thereby. The auto-transformer of motor is mounted on the rear of the switchboard and is controlled by a special double throw switch on power panel. The generator is a six-pole, compound wound unit which is designed for operation at 580 r.p.m., and to deliver 230 volts direct current, and is fitted with collector rings for use in connection with balance coils for supply of 115 and 230 volts on the 3-wire system.

The generators and the distribution circuits of the plant are controlled upon a handsome marble switchboard of eight sections, of which there are one each for lighting and power, both direct current and alternating current, while the remaining four are devoted to generating machinery, two for the alternators and one each for the exciters and direct current generator of the motor generator set. The alternating-current lighting section of the board which controls the principal lighting supply for the building contains 38 circuits which are of from 50 to 200 amperes capacity and extend to distributing panel boards in different sections of the building. From the direct-current lighting section there are five circuits controlled, two of which are of 50-ampere capacity and three 100-ampere, these current supplies being used for experimental and special service in various portions of the building. From the power sections, there are 12 circuits, ranging from 100 to 300-ampere capacity, that extend from the alternating-current power section of the board, one to the motor generator set and eleven to the laboratories and machinery sections of the building for operation of induction motors, and five circuits from the direct-current power section to the elevator motors, boiler feed and vacuum pumps, and to the laboratories where variable-speed, direct-current motors are used. The power service of the plant consists of a connected load of about 80 motors ranging from ¼ to 35-h.-p. capacity each, of which eight are variable-speed, direct-current motors used for machine tool drives, and two for the elevators, and a connected load of about 4,500 incandescent lamps. The greater part of the machinery and tools in the laboratories are driven by inverted ceiling motors of the alternating current induction type.



Plan and Section of Engine Room of Stuyvesant High School.

Almost the entire mechanical equipment of the high school has been selected and installed with special reference to its use for demonstration purposes for the students, enabling instruction in operating methods and tests to be made in connection with apparatus working under regular operating conditions. Steam and coal calorimeters, apparatus for testing oils, indicators and other instruments of precision are furnished for investigation purposes and tests of the power equipment are provided for by water meters so installed in the feed piping as to determine the quantity of water fed to the boilers and to measure the returns from the heating system, pyrometers placed in the smoke flues leading to and from the economizers to permit of temperature readings of the flue gases and thermometer wells in the water lines to indicate the temperatures of the feed water in all stages of the feed circuits.

The Stuyvesant High School building was designed, together with its entire mechanical and electrical equipment, by the Board of Education of the City of New York, of which Mr. C. B. J. Snyder is Architect and Superintendent of School Buildings. The steam plant and power equipments were designed under the direction of Mr. F. G. McCann, Chief of the Heating and Ventilating Division, while the electrical equipment was designed by Mr. S. A. Thomas, Chief of the Electrical Division of this bureau. The steam and mechanical equipment were installed by Blake & Williams, New York. Messrs. Peet & Powers, New York, were contractors for the electrical equipment and the wiring installation.

(To be Continued.)

Heavy Excavation at Bingham, Utah.

Unusual mining operations are being conducted at Bingham, Utah, where the Boston Consolidated Mining Co. and the Utah Copper Co. have installed equipment for razing a mountain of "porphyry" ore at the rate of 10,000 tons per day. The yearly production of copper from this quantity of ore is estimated at 80,000,000 lb. The Boston company is mining exclusively with steam shovels of 3 and 5 cu. yd. capacity and expects to continue this method. The Utah company is mining with steam shovels and also by the caving system, but expects gradually to abandon the latter method. The Bingham ore is favorable material for steam shovel operation and this work is similar in detail to steam shovel mining in Michigan and other states. The ground is loosened by shooting drill holes put down with Keystone drills to a depth of 150 or 160 ft. or with Ingersoll drills to a depth of about 20 ft. As much as 225,000 tons has been loosened by a blast of nine deep holes at a powder cost of 1.5 cents per ton. The caving system as practised at the Utah workings is simple and efficient, according to Mr. W. R. Ingalls, in "The Engineering and Mining Journal." The face of the mountain side is cut up by drifts and crosscuts into blocks 50 or 100 ft. square, generally the former. From the main level raises or mill holes are put up to the cap-rock at an angle of about 55 deg. Sub-levels are opened at vertical intervals of 30 to 33 ft. The caving is conducted from the top downward, block by block. In starting the cave in any block, raises are put up from the sub-level next below opening into the block to be caved with funnel-shape tops, and stopes are opened into the block from the sub-level on which the caving is to be done. The stoped ore falls down into the funnel-shape openings of the mill holes and is drawn off through chutes into cars on the sub-level next below, or perhaps lower down, and is trammed to the nearest main raise, through which it is dropped to the main level. These raises are made at the angle of 50 to 55 deg., because at that the ore slides down freely and can be handled most easily. Caving is begun at the top and is brought downward step by step in a broad section. About 40 per cent. of the ore is taken out in drifting, raising and stoping and the rest is caved down very easily. In the Utah mine conditions are favorable to the caving system. The ore stands about 15 cu. ft. to the ton. Wages are: Machinemen, $3.25 and helpers $3 per 8 hours; hand-steel miners, $2.75 and $3; muckers and hand trammers, $2.75; timbermen, $3.25. Under these conditions Mr. Ingalls estimates the cost of the mining in the regular way at $1.20 or less per ton and the caving is said to be costing less than 15 cents per ton, the composite cost per ton being about 57 cents. The cost with steam shovels is estimated at about 25 to 30 cents per ton of ore, this including the cost of handling cap-rock.

A New Floating Dry Dock, which will take vessels up to 18,000 tons, has been put in commission at Rotterdam, Holland. It measures 565 ft. over all, has a clear interior width of 88 ft. at the bottom and 96 ft. at the top, and a height above the floor of 36½ ft. The seven pontoons which float the structure are independent of each other, and can be separately brought up inside the dock. Each pontoon is fitted with two electrically-driven centrifugal pumps. The total weight of the structure is about 6,500 tons.

Doubling a Factory's Floor Space.

By C. M. Ripley, New York.

An interesting piece of factory construction has just been completed at Passaic, N. J., at the factory of the Pantasote Leather Co., for the manufacture of the well-known substitute for leather. Salmond Brothers Co., of Arlington, N. J., have made a record not only in the speed with which they have added 42,000 sq. ft. floor space, but by their display of ingenuity in enveloping a one-story, 65 x 85-ft. wing of the old factory, by a two-story modern brick structure covering three times the ground space of the old wing, a piece of work that was completed in 80 days, entirely effacing the old structure, although the machinery in it was in continual operation.

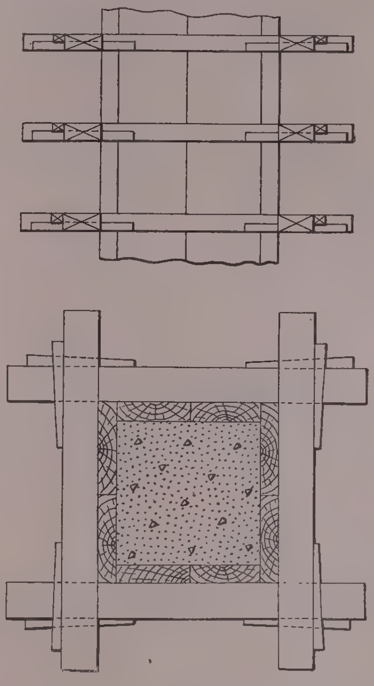
The wing of the old factory which was enveloped by the new, was known as the embossing mill, where four ten-ton machines were embossing the pantasote and giving it the external appearance of leather. On Sept. 26 the contractor was admitted to the embossing mill on the understanding that the machines must be kept running continually (excluding Saturday and Sunday) with the exception of a two-day shut down. It was during this short time that six reinforced concrete piers 6½ ft. square were sunk 14 ft. deep and the necessary excavation made inside of sheet piling in order to furnish new foundations, partly under the embossing machines, for the columns of the heavier two-story structure being erected. In this brief time, also, the contractor, by an ingenious and original scheme which is shown in a sketch, supported the heavy 4-in. line shafting supplying power to the embossing machines, by means of vertical struts and cross timbers which held the shaft hangers firmly in their original place after the roof of the old factory had been torn away.

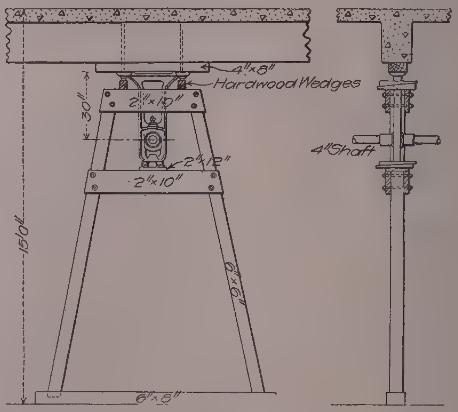
On Sept. 29, the mill was again running at full capacity and the forms for constructing the concrete girders and the second floor were put up in five days more. In the succeeding four days' time, the second floor concrete was laid over a 68 x 140-ft. surface. In a total of 14 days after the contractor was admitted to the embossing mill, the roof of the second story was being constructed and on Oct. 26, just one month after starting their portion of the work, the roof was completely finished, including a monitor skylight. On Nov. 2, or six days later, the interior was finished and new machinery being installed.

The sketch of the method adopted by the Salmond Bros. Co. to support the line shafting while the old roof was being torn away will probably be of interest to factory managers. This work will be seen to be exceptionally difficult when it is considered in relation to the new structure. The change from the old building to the new building was effected without moving the machines, without lengthening or shortening a single belt; and, in fact, without deranging in the least the old layout of the embossing machines, line shafting or any other apparatus. It thus follows that the new building had to be built so as to suit the machinery, reversing the general order of installing the machinery in accordance with the lines of the factory interior. The sketch, therefore, illustrates how the contractor rigidly held this 4-in. shaft and the hangers in place without being allowed any head room and, under the further difficulty of providing space for wooden forms in which the reinforced concrete girders and roof had to be moulded. The wooden pads to which the hangers were later to be bolted when the factory was completed, it will be seen, were made to act also as the bottom of the wooden falsework upholding the wet concrete, which, when set, would support the hangers through the pads. Moreover, the floor girder was constructed at such a height as to support the hanger ultimately in exactly its old position after the new building was completed.

It will be noticed in the sketch of the column forms that the complete box for a column is put snugly in place with close joints without the use of any nails whatsoever with the exception of light 4d nails used now and then to tack in place the wedges. A further advantage resulting from this construction method is that the salvage from the lumber is practically 100 per cent. Since the small nails are merely used as tacks and only partially driven in place, they can easily be withdrawn from the wedges, and these in turn can be removed for use again by a slight tap of the hammer. Then the entire mold can be removed from the concrete column, after it has sufficiently set, and the boards are in perfect shape, neither pierced nor penetrated to the slightest degree by a single nail, nor subjected to the damaging effect of nail pullers nor the alternative of prying the boards off with a jimmy. In this factory construction there were fifty-six columns in which this method of clamping the forms was adopted.

The conclusion to be drawn from the above description is that the Pantasote Leather Co. has doubled its floor space in less than three months; that it has done this with an increased ground space only approximately 65 per cent. larger than the original space occupied; that this increase was made not through the expedient of any additional stories to buildings already in existence, but was carried out partially by replacing a wing of the old structure one story in height by an entirely new building two stories in height; and this was accomplished, in addition to the complete wrecking and removing of that portion of the old building enveloped, without interfering with the operation of that portion of the plant suspended from the roof of the old structure or that portion resting upon the floor of the old structure.





Column Forms and Shafting Supports Used in Increasing Factory Space.

An Electrically-Operated Shovel is used in maintenance work on the Western New York & Pennsylvania Traction Co., an electric interurban line, and is reported to have proved economical in labor and operating costs. The shovel is of Vulcan make, with a 1¼-yd. dipper, and is equipped with a 50-h.-p. hoisting and two 20-h.-p. auxiliary motors of the railway type using trolley line current. It is geared to cut 25 ft. wide at rail level. and lift to a clear height of 12 ft. It is operated by inexperienced labor.

Smoke Prevention at Newark, N. J.

As a result of the general use of bituminous coal for steaming fuel during the anthracite coal strike of 1903-4 and the subsequent scarcity of that fuel, there has been considerable activity in Newark, N. J., in regard to smoke prevention. Bituminous coal is largely used by the many manufacturing plants there and, as insufficient attention has been paid to smokeless combustion, very smoky conditions in the city have been the result. The original agitation for smoke prevention resulted in the creation of a city department of smoke abatement and the passage on Dec. 10, 1906, of an ordinance to regulate the emission of smoke from chimneys, in which the violations were based on a color scale for determination of the nuisance. Legal difficulties were experienced in the enforcement of penalties for violations, due to certain indeterminate features of the color scale. For this reason a new ordinance was adopted May 22, 1907, in which the color scale is abandoned and different methods adopted. This new ordinance reads as follows:

"Be it ordained, by the Common Council of the city of Newark as follows:

"Section 1. That it shall be unlawful to permit the emission of dense smoke from any smokestack or chimney connected with any stationary engine, steam boiler, locomotive, steam roller, steam derrick, or other similar machine, or from any smokestack or chimney of any apartment house, office building, institution, establishment, place, premises, or any building used as a factory or for any purpose of trade, or other than a private residence, or from any tar kettle, or other machine, furnace or contrivance within the corporate limits of the city of Newark, which smoke contains soot or other substance in sufficient quantities to permit the deposit of such soot or other substance on any surface within the limits of said city.

"Section 2. Be it further ordained, that any owner, agent, manager, lessee or occupant of any building within the limits of the city of Newark, to which is attached any chimney, or smokestack, connected with any stationary engine, or steam boiler, or of any apartment house, office building, institution, establishment, place, premises, or buildings used as a factory, or for any purpose of trade, or other than as a private residence within the limits of said city, and any owner or manager of any locomotive engine, steam roller, steam derrick, or tar kettle, or other machine, furnace or contrivance within the limits of the city of Newark, who permits or allows to be emitted from any such chimney or smokestack, locomotive engine, steam roller, steam derrick, tar kettle or other machine, furnace or contrivance, dense smoke which contains soot or other substance in sufficient quantity to permit the deposit of such soot or other substance on any surface within the limits of the city of Newark, shall, upon conviction thereof, in a court of competent jurisdiction, be fined not less than twenty-five dollars, nor more than fifty dollars, or be imprisoned in the county jail for ten days, at the discretion of said court. Each and every day said smoke shall be emitted shall be deemed to be and shall constitute a separate violation of this ordinance.

"Section 3. That there shall be and hereby is created the position of smoke inspector at a salary of fifteen hundred dollars per annum, payable as other salaries are paid. This officer shall be appointed by the Common Council. He shall be a citizen of the United States and a resident of the city of Newark. His regular term of office shall be for two years, and until his successor is appointed and has qualified. It shall be the duty of the smoke inspector to personally inspect all chimneys, smokestacks, and other appliances for the escape of smoke, and he shall have authority in the performance of the duties of his office to enter any steam boiler, furnace or engine room of any building not occupied exclusively as a private residence, and any person or persons hindering or obstructing him in the performance of such duties shall upon conviction thereof in any court of competent jurisdiction be fined not less than ten dollars nor more than fifty dollars.

"Section 4. The smoke inspector shall make written reports of his work of inspection weekly to the City Clerk of the city of Newark.

"Section 5. If the emission of dense smoke containing soot or other substance, be due to the construction of the furnace, size or height of stack, connections, or other engineering details relating to boiler or furnace construction, or connection, or the emission of such dense smoke may be prevented by the use of some proper device, and the owner or owners, lessee or lessees, or manager thereof, shall apply to the smoke inspector for time to make alterations or changes, or to install such device, and shall file with the smoke inspector a plan of the proposed alterations or changes, or a statement or plan of such device, the smoke inspector, if he approves such plans or such device, shall stamp them approved, and shall give thirty days' time from and after his approval to make such alterations or changes, or to install such device; and if at the expiration of said thirty days, such alterations or changes are not completed, or such device not fully installed, the smoke inspector, if satisfied that the owner or owners, lessee or leessees, or manager, are acting in good faith, and have been unable to complete such alterations or changes, or fully install such device within the said period, may extend the time for such alterations or changes, or installation, not to exceed in all four months from the first approval of said plans or said device, and during such time, such owner, or owners, lessee or lessees, or manager, shall not be held liable for a violation of this ordinance; but the approval of any such proposed alterations or changes, or device, shall not relieve such owner, or owners, lessee or lessees, or manager, from liability for violation of sections one and two of this ordinance, if such alterations, changes or device when completed or installed, fail to prevent the emission of smoke of the kind prohibited by this ordinance."

The work of inspection was begun soon after the passage of the ordinance, and as a result of it a number of large power users, including office buildings and industrial plants near the business center of the city, have returned to the use of anthracite fuel, while others have been successful in abating smoke by improved methods of firing, by changes in the furnaces or apparatus, or by the use of special apparatus for improving combustion. An equipment of the latter type is in successful use at the cold storage and milling plant of Wilkinson, Gaddis & Co., a large wholesale grocery and provision company in Newark, and while the apparatus is not new, it is of interest, because its sale has only recently been pushed and this mill was formerly an offender in the production of smoke.

The boiler plant at the mill is one of but 150-h.-p. capacity and is rarely worked to an economical loading, so that the installation of a stoker equipment or the use of anthracite fuel was not desirable. The Thomas automatic smoke preventer installed is a device for intermingling the volatile hydrocarbons from freshly-fired coal with sufficient oxygen for complete combustion. It was used at the Battery Park power plant of the New York Tunnel Co., contractors for the Brooklyn extension of the Rapid Transit Subway, who for over two years burned bituminous coal under boilers aggregating 1,200 h.-p. in a location in the city where a smoke nuisance would have been most offensive, but without interference from the New York City Health Department. As it can be applied to an existing boiler furnace without changes in the setting of any great importance, it was adopted for use in this plant.

The Wilkinson, Gaddis & Co. plant is located at Murray St. and Tichenor's Lane and consists of a cold storage and freezing building for the storage of eggs, cheese and butter, and a grain elevator and grist mill, between which is the power plant. The latter consists of a horizontal return tubular boiler of 150-h.-p. rated capacity, which furnishes steam to a 50-h.-p. Corliss engine that runs the mill and a 30-ton absorption ice machine and numerous pumps. The boiler is a domeless shell 18 ft. in length by 6 ft. in diameter and is operated under a working pressure of 90 lb. It is brick set and has a 6 x 6½-ft. grate fitted with Tupper extra heavy grate bars, having ⅜-in. air spaces, behind which is a 12-in. bridge wall rising to within 18 in. of the shell. The furnace is hand fired, with a low grade of bituminous coal, containing 22 per cent. of volatile matter and costing $1.50 per ton at the mine, or $3.35 delivered at the plant.

The Thomas device operates on the steam jet principle, in which blasts of superheated steam from numerous jets draw in air through openings in the firing doors, for mingling with the volatile gases given off from the freshly fired fuel, to insure their proper combustion and preventing smoke. There is, however, incorporated with it a mechanism which has for its purpose the operation of the jets only at such times as the volatile gases are being given off and the jet action is of advantage, shutting them off and economizing steam when the volatile gases have been driven off and satisfactory combustion conditions obtained. This is accomplished by a dash pot mechanism actuated by the opening of the fire doors for throwing in fresh fuel or for stoking the fire, which mechanism allows the jets to blow for a predetermined length of time, and then shuts them off. The mechanism consists essentially of a shaft mounted horizontally across the boiler front a few inches above the fire doors and connected to the latter through knuckle-joint rods with slip sleeves so adusted that whenever either door is opened, further than about 15 deg., the shaft is rotated, a full opening of either fire door turning the shaft approximately 90 deg. This motion of the horizontal shaft opens a lever throttle valve in the steam line that admits steam to the jets, while the dash pot which is connected to the shaft through a crank and rod motion and allows free action of the shaft in opening the doors, delays the closure of the steam throttle valve for a definite period of time after the fire doors are shut. An action incident to this movement of the shaft and dash pot is the opening of large air dampers in the firing door fronts, which is accomplished by a cam and lever mechanism so adjusted as to keep the dampers fully opened whenever the steam jets are in action; these dampers open into the hollow spaces behind the fire door baffle plates, which, with this device, are specially constructed, containing for each door approximately 250 small holes, through which fresh air is admitted to the fire.

The application of the device to the boiler at the Wilkinson, Gaddis & Co. plant is indicated in the accompanying drawings. The front of this boiler has a double fire door, with an exceptionally large total opening, measuring 16 in. in depth at the middle, and 40 in. in length, which renders the conditions for satisfactory operation less favorable than if two separate doors were used with alternate firing. The dash pot here used is of the oil type and has its by-pass adjusted to permit closure in about 90 seconds, in which the full rate of flow through the steam jets continues for only about one-half this time. The details of the knuckle-joint connections from the doors to the horizontal shaft and also the connections from this shaft to the dash pot plunger and to the lever operating the air dampers have been simply worked out, as shown. There are 16 jets used in this setting, each of which consist of a pipe with a ⅛-in. hole that is screwed into a ¾-in. header, into which the steam is delivered. This header with the jet is enclosed in the brickwork of the setting above the firing doors, as indicated in the drawings, the jets being so directed as to impinge against the front side of the bridge wall for thorough mixture of the gases above the fire. To permit free expansion and contraction in the setting, the jet tubes are inserted in sleeves of ⅜-in. pipe, which are cemented into the settings and thus allow slight movement of the header and jet pipes during temperature changes. The air dampers in the fire doors are in this installation much smaller than generally applied in this device, having but a 6½ x 10-in. opening, which is the largest that the construction of the doors would admit of. The Thomas device was installed by the Automatic Smoke Prevention Co., 107 West 17th St., New York.

In a number of observations of the action of this device at the plant of Wilkinson, Gaddis & Co. satisfactory results were noted. When the mechanism was detached from the fire doors and placed temporarily out of commission the furnace gave, with the above mentioned coal and ordinary firing, large quantities of dense black smoke, which in all cases continued to flow from the stack for periods upward of five minutes after each firing of fresh coal or slicing of the fire. When the device is connected smoke appears from the stack for short periods only after each firing or slicing, but in much less offensive form, the gases being but slightly colored by carbon and radically different from the offensive dense black smoke produced before; the periods during which this light smoke is given off varied in a large number of observations from 20 seconds to slightly over 1 minute, when fresh fuel is charged, and from only 20 to 30 seconds when the fire is sliced. An intersting test of the effectiveness of the device was made by suddenly turning on the steam jet and opening the air dampers at a time when the furnace was being operated without the device and producing dense black smoke; in such instances the smoke was reduced to a light vapory form almost instantly after starting the jets, the black smoke continuing for approximately 10 seconds after starting the jets, which is, it is figured, the length of time necessary for the dense smoke that was in the flue and stack to clear itself out.

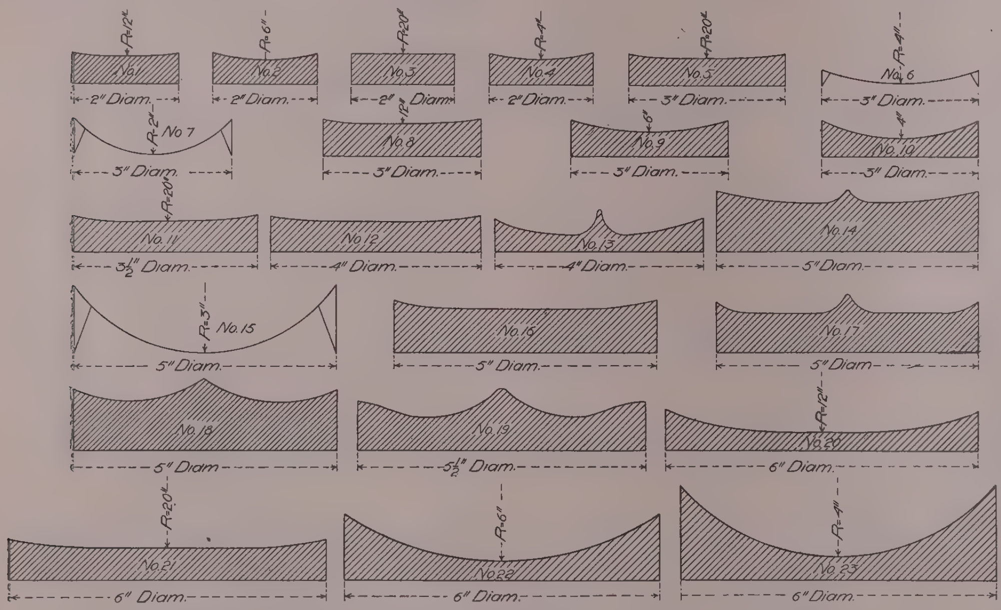
THE COST OF HAULING COAL for its own locomotives is estimated at 3 mills per ton-mile on the St. Louis & San Francisco R. R., and the labor of handling it at 8 cents per ton.

Sewage Distributors for Sprinkling Filters. Part II.

Determination of Coefficients, Gravity Distributors.—The system of gravity distribution involves the discharge of the sewage from openings in the bottom of troughs onto concave disks placed below, the discharged stream having sufficient force to splash up and out from the disks in a fine spray.

The splashing disks first used on the Institute of Technology trickling filter in 1905 were of metal, 3 in. in diameter, and with a concavity corresponding to a radius of curvature of 6 in. These were at first placed only 5 ft. apart, with a discharge on each disk of less than 0.9 gal. per minute. This discharge proved too low for good distribution and a single disk was substituted for four on each 100 sq. ft. of area, giving 10 ft. between disks and a discharge on each of 3.47 gal. per minute. This proved more satisfactory, and the experimental filter thus equipped gave very satisfactory results even through the severe winter of 1906-1907.

With gravity distributors there are three distinct variable factors, the rate of discharge, the distance between the trough and the disk, and the distance between the disk and the filter below. In the experiments all three have been varied independently. For rates there were used the three standard discharges described above, corresponding respectively to 1.71, 4.08 and 8.47 gal. per minute. For the total head between the trough and the measuring tank (corresponding to the filter surface) three standard heads were used, 2, 4 and 6 ft.; and with each of these heads three different positions of the disk were tested. With the 2-ft. total head the head-on-sprinkler was made 6, 12 and 18 in.; with the 4-ft. total head the head-on-sprinkler was made 1, 2 and 3 ft.; with the 6-ft. total head the disk was placed at 1, 2½ and 4 ft.

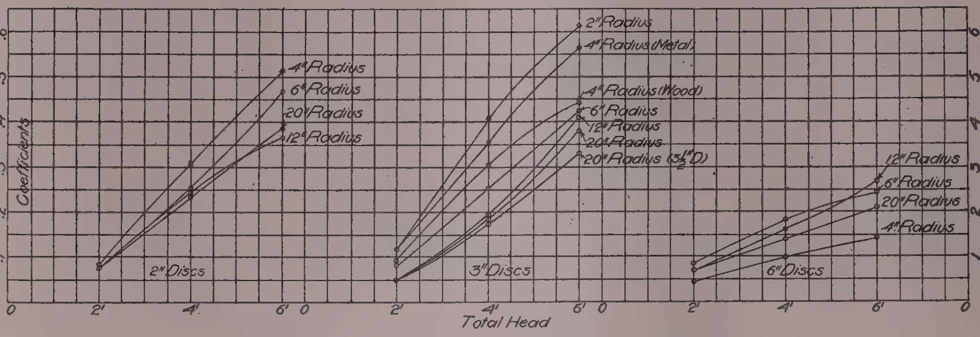


Splashing Disks, Used in Experiments on Sewage Distributors.

Besides these three variable factors the efficiency of gravity distribution depends upon the design of the splashing disks themselves. Twenty-three types of disks were tested in the experiments, varying in size and curvature, in the hope of finding some more favorable design than the simple concave type first used. Cross-sections of the disks examined, with their respective dimensions, are shown. Nos. 1 to 4 were wooden disks 2 in. in diameter, with surfaces of different radii of curvature from 4 in. to one of 20 in. Nos. 5 to 10 were disks 3 in. in diameter, Nos. 6 and 7 of metal and the rest of wood, the radii of their concave surfaces varying from 2 to 20 in. Nos. 11, 12 and 16 were larger, very shallow wooden disks. Nos. 13, 14, 17, 18 and 19 were wooden disks whose upper surfaces were concave about a central raised point, rising again all around their outer edge. This design is called the mushroom disk. No. 15 was a large, deep metal disk, 5 in. in diameter, and with a 3-in. radius of curvature. Finally, Nos. 20, 21, 22 and 23 were large, 6-in. wooden disks with radii of curvature varying from 4 to 20 in.

Some of the disks produced good distribution within a small circle, but the rate on the wetted area was so great as to be excessive. By reducing the crude coefficients for such disks so as to bring the total rate down to 2,000,000 gal. per acre per day, the corrected coefficients have been estimated. (Tables of these coefficients are given in the paper but are not reproduced here as the diagrams of their relations are sufficient for this review.) This was done for the three rates of discharge tested as follows: A discharge of 1.71 gal. per minute on each splashing disk corresponds to 2,480 gal. per day per disk. At a 2,000,000-rate this requires 808 sprinklers per acre, or one sprinkler to each 54 sq. ft. of filter area; the distance between sprinklers must therefore be 7.35 ft. Similarly the 4.08-gal. rate would require 341 sprinklers per acre, or one to each 128 sq. ft., and the distance between sprinklers must be 11.3 ft. The 8.47-gal. rate calls for 164 sprinklers per acre, or one to 266 sq. ft., with a distance of 16.3 ft. between sprinklers. All coefficients have therefore been corrected by referring the actual discharges to squares respectively 7.35, 11.3 and 16.3 ft. on a side.

The efficiency of gravity distributors is markedly influenced by the rate of discharge on each disk, and about 4 gal. a minute is the most favorable rate. The lower rate, 1.7 gal. per minute, gave very poor results with the larger disks, the liquid merely dripping over the edge. With the smaller disks fairly good results were obtained within a radius of 3 or 4 ft. of the disk, although there was generally an excess of discharge nearest the center. As the distance between sprinklers for this head was only 7.35 ft., the crude coefficients of 0.6 and 0.7 were not so greatly reduced as in other cases, and for the 2-in. disks this rate is better than either of the higher ones. Most of the 2-in. disks gave corrected coefficients of over 0.4 even with the 6-ft. total head, and coefficients of over 0.5 were obtained for disks 4, 6 and 10.



Coefficients of Distribution for Gravity Distributors.

The intermediate rate of 4.08 gal. per disk per minute did not suit the 2-in. disks as well as the lower rate, but with larger disks it gave better results. With good heads the liquid was well distributed, showing neither the concentration near the disk obtained with the lowest rate nor the marked outer ring characteristic of the higher one. Crude coefficients of over 0.7 were obtained with almost all the disks by using a 6-ft. head, and the better ones ranged between 0.8 and 0.9. Furthermore, the wetted area was proportionately larger than with the higher or the lower rate of discharge; 4.08 gal. per disk per minute calls for a distance of 11.3 ft. between sprinklers, and with high heads the better disk wetted circles 10 and 11 ft. in diameter. The corrected coefficients remained, therefore, relatively high, several of the disks showing values over 0.5, and one, disk No. 7, over 0.6.

With the highest rate the better disks covered a 10-ft. circle, but there was usually a ring of excessive discharge at a distance of 3 or 4 ft. from the center. The larger disks, at high heads, gave crude coefficients of between 0.7 and 0.8, wetting a circle of 6 ft. radius. Corrected for a 16.3-ft. square these crude coefficients are seriously reduced, only two of the corrected coefficients being over 0.3.

The head used with the sprinkler disks was a most important factor in controlling their efficiency. The 2-ft. total head proved inadequate in most cases. Some of the crude coefficients were fairly good (between 0.6 and 0.8); but the wetted area was always much too small, giving an excessive rate near the sprinkler, and the corrected coefficients were almost always under 0.1. The 4-ft. total head showed better results, and the 6-ft. better still, the improved efficiency being directly proportional to the increase in head. This relation is indicated graphically in the diagram for the disks of 2, 3 and 6-in. diameters at the best rate of 4.08 gal. per disk per minute.

With regard to the best proportion of the total head to be used in the discharge above the disk, results are somewhat more variable. Increasing the head on the disk gives an enlargement of the wetted area, but it apparently brings about also an increased tendency to concentrated discharge in a single zone. With a 6-ft. total head a head-on-sprinkler of 2½ ft. is most favorable for the shallower sprinklers, and a value of 4 ft. is better for the deeper ones. The 1-ft. head-on-sprinkler is always inadequate to secure a proper splashing discharge. These results are indicated with greater clearness in the diagram, where the coefficients for the best rate (4.08 gal. per minute) and best total head (6 ft.) are plotted for the three values of head-on-sprinkler which were tested.

There remains still to be considered the influence of the shape of the splashing disk itself. Two general patterns were studied—simple concave plates and disks of the "mushroom type" with a raised central cone (Nos. 13, 14, 17, 18 and 19). The latter show coefficients intermediate between the large and small concave disks, better than the former and not so good as the latter. In other words, the slope on one side of the central boss deflects the water very much as a simple cup of similar size and curvature would do. The discharge from these disks was, however, unequal along different radii, since it was almost impossible to make the stream of liquid strike the central boss. The coefficients are therefore higher than they would be, since the revolving trough caught portions of unequal discharges in different zones along the various radii. There seems to be no advantage in the use of disks of this pattern.

There remain the simple concave plates, varying in diameter and in radius of curvature. For diameter, 3 in. is the most favorable size. A comparison of the three sets of curves in the diagram of the relation between total heads and coefficients shows that the 3-in. disks (Nos. 5, 6, 7, 8, 9 and 10) are better than the 2-in. disks (Nos. 1, 2, 3 and 4), and far superior to the larger ones (Nos. 20, 21, 22 and 23). These figures relate to the 4.08-gal. discharge. At the lower rate (1.71 gal. per disk per minute) the 2-in. disks giver higher coefficients than the 3-in. ones. This might be expected, since poor distribution with large disks arises from the fact that the liquid has not force enough to splash freely off, but pools and drips over the edge.. The smallest disks are therefore best suited to low discharges, but the 3-in. disks and 4.08-gal. rate form the best combination.

Efficiency was found to increase with the increasing concavity of the disks.

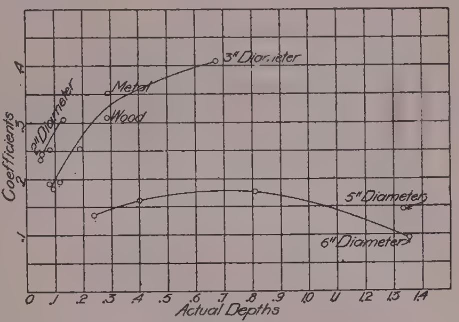
The improvement with increase in curvature is most marked with the disks of small diameter, and with the 6-in. disks the 12-in. radius of curvature is the maximum, the 4-in. radius giving very poor results. This is brought out more clearly in the diagram of the relation between depths and coefficients for disks of different diameters, where the coefficients at the 4-ft. head are plotted. An increase in concavity increases the efficiency of the disk by breaking the liquid up more completely and sending it higher into the air. The accompanying increase of disk surface over which the liquid must travel tends, however, to decrease the efficiency of distribution, probably by the greater friction involved. With small disks this is not serious, but as the surface is increased this factor limits the possible increase in concavity. Disk No. 15, with a diameter of 5 in. and a radius of curvature of 3 in., represents an extreme condition in which the liquid did not splash at all, but eddied about in the deep cup and merely dripped over the edge.

Of all the disks studied, the best was No. 7, a metal cup, 3 in. in diameter, with a radius of curvature of 2 in. With a total head of 4 ft. and a head-on-sprinkler of 3 ft., it gave a coefficient of 0.40, the best obtained with that total head; and with a total head of 6 ft. and a head-on-sprinkler of 4 ft., it gave the highest coefficient obtained for any gravity distributor, namely, 0.62.

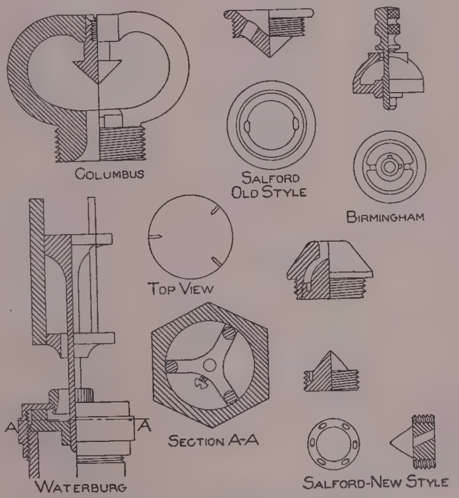
Determination of Coefficients, Pressure Distributors.—The distribution of sewage from sprinklers was adopted more or less independently at a number of British cities some time ago, and since then various types of nozzles have been devised. A critical study of the more important types has been made at the Massachusetts Institute laboratory by the same method of measuring their efficiency that was followed with the gravity distributors.

The Salford nozzle (old style) is a brass nozzle in the form of a cup, with two openings in the sides at such an angle that the streams discharged upward from them meet in the cup itself. Its construction is shown in one of the sketches.

This nozzle differed from all others tested in the fact that it did not discharge equally along different radii. It threw the liquid up in a fan-shaped spray, in quite a narrow plane. The method of rating efficiency which assumes symmetrical distribution about the centre was of course inapplicable under such circumstances. Instead, therefore, of revolving the measuring tank about this sprinkler, the discharge was measured at six different stationary positions, immediately adjacent to each other and together covering one-half of the entire circle surrounding the distributor. The average discharge in each zone was used in the manner described above for calculating the crude coefficient. Then the mean discharge along each sector was determined, and from this the total excessive discharge along those sectors which received more than their share. The ratio of the excessive radial discharge to the total discharge was then determined and taken from unity, giving the "radial coefficient." The product of the crude coefficient and the radial coefficient measures the evenness of distribution within the wetted area.



Effect of Concavity on the Coefficient.



Pressure Distributors Tested.

When this sprinkler nozzle was tested under a head of 6.4 ft., another anomaly appeared in connection with the determination of the corrected coefficient. The area wetted was larger than the square which would be tributary to each sprinkler at a 2,000,000-gal. rate. This means, of course, that at this head and rate the circles would overlap. The following method of calculation was applied in this case and in others of the same kind.

The effect of overlapping circles of spray is exactly the same as it would be if each portion of the spray passing the boundary of the tributary square were perfectly reflected at the side of that square and returned to a corresponding point within. It is necessary, therefore, to calculate how much of the discharge into the outer rings would have been thus reflected, or, in other words, what porportion of each of the overlapping rings falls without the square. Given the dimensions of the square and of each ring, this is a simple problem in trigonometry. Having subtracted from all the rings the amounts which would be reflected, it is next necessary to distribute these amounts among the inner rings where they properly belong. The mathematical solution of this problem gave a result too cumbrous to use. A graphical representation of the conditions drawn on plotting paper, however, indicated readily and with sufficient accuracy the amounts of the reflected discharge which would fall into each of the inner rings affected, and the reflected water was then redistributed. These new values were then recalculated like the others and a coefficient obtained, which referred, not to a circle, but to the area common to the maximum circle and the intersecting square. The relation between this area and that of the square furnished the required factor for the calculation of the corrected coefficient from the crude.

One very interesting point about this nozzle is that the discharge with a head-on-sprinkler of 6.2 ft. was less than with a head-on-sprinkler of 3.9 ft. This is apparently due to the fact that the two converging streams discharged by this nozzle meet in its cup with such force as to produce a back pressure, which at high head cuts down the flow appreciably.

This nozzle secures a fairly even distribution within the wetted sector, improving with the head to a very high value. There is an area of excessive discharge near the outer limit of the wetted sector, but the excess is not great. The inequality of distribution along different radii is much more serious. Nearly half the liquid is discharged in excess on one of the six 30° sectors and this weakness causes the corrected coefficients to be poor.

The Salford new style sprinkler tested is a double cone the outer cone being open at the top. The liquid enters the space between the cones through six holes of 5/32-in. diameter, inclined at an angle to the major axis, so that a spiral motion is produced within the inner cone. This sprinkler is shown in one of the sketches.

With this, as with the other pressure nozzles, distribution along different radii was approximately equal, and tests were made by revolving the measuring tank about the distributor. As in the case of the old Salford nozzle, at high heads a wetted area was obtained extending beyond the sides of the calculated tributary square, and the factor was therefore corrected by the method described above.

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The results of these tests indicate that the new Salford sprinkler gives very good results at the higher heads. The tests themselves show an excessive discharge on the outer part of the wetted area, but the excess is small, giving crude coefficients of 0.6 and 0.7 at 3.8-ft. and 6.1-ft. heads. At the 3.8-ft. head, however, the wetted area (a circle of 3 ft. radius) is small in proportion to the rate. The corrected coefficient is therefore poor, while that obtained at the 6.1-ft. head, with only slightly higher rate and a circle of 4 ft., remains in the neighborhood of 0.7.

The Birmingham nozzle, shown in one of the sketches, discharges through a 3/8-in. opening. Through this opening passes a 7/32-in. shank, the enlarged upper portion of which breaks up the ascending ring of liquid and sends it out in a fine spray. In this case the discharge through the opening was so small and the distribution so good that a circle larger than the proper tributary square was wetted in every test except those made at the 2.2-ft. head. The results are therefore corrected, as in the cases above.

With a low rate of discharge, due, of course, to the obstructive construction of the orifice, a relatively large circle was covered (of 2.5 ft. radius at the 2-ft. head, 4 ft. radius at the 4.1-ft. head, and 5 ft. radius at the 5.8-ft. head); and within this circle the distribution was remarkably even. With this nozzle the 4-ft. head proved better than the higher one, since at the 5.8-ft. head a more definite ring of excessive discharge was formed. Under the best conditions this nozzle gave corrected coefficients of 0.7 to 0.8. It is clear that the Birmingham nozzle effects a far more perfect distribution than any other device examined.

The Columbus nozzle is designed on a plan exactly opposite to that of the Birmingham sprinkler, in so far as it aims to enlarge the orifice of discharge as much as possible. The Columbus design is shown in one of the sketches.

The Columbus sprinkler shows at all heads a fair distribution within the wetted area, its departure from the ideal condition being due to the formation of a zone of excessive discharge a little inside the periphery of the wetted area. Crude coefficients, however, are always about 0.6, and one notable thing about this nozzle is the fact that it gives fairly even distribution even at the 2-ft. head. The wetted area is, however, small in proportion to the discharge, and therefore the corrected coefficients are poor. Thus at the 4.3-ft. head, for example, the rate of discharge of the nozzle was 10.9 gal. per minute. This discharge, if the total rate on the filter be 2,000,000 gal. per acre, calls for 121 sprinklers per acre, which means a distance of 19 ft. between sprinklers. The wetted circle at this head was only 6 ft. in radius, so that at an ostensible 2,000,000-gal. rate half the filter area would be working at 4,000,000 gal. and the rest would be idle. It is no doubt for this reason that the Columbus engineers plan to operate at a 4,000,000-gal. rate for half the time, and to rest the whole filter the remainder of the time, spacing their nozzles 16.2 ft. apart. This would, of course, give a distribution more nearly approaching our crude coefficients, though the results at best would be below 0.6.

The Waterbury nozzle used in these experiments was of the type indicated in one of the sketches. Briefly the nozzle consists of two cones, one above the other, the lower one perforated at its centre. An annular discharge is in part deflected outward by the lower cone, while its inner portion passes through the lower cone and is deflected by the upper one. The result is to produce two concentric cones of spray and thus improve the distribution obtained with a nozzle of the Columbus type. In the sprinkler tested, the position of each cone in relation to the point at which the liquid leaves the pipe below could be varied by means of set screws, and a number of different settings of these cones were examined.

The tests were all made with water, but the tanks through which it was pumped were not perfectly clean and at times contributed their quota of old sewage sludge. These inequalities did not, however, seriously affect the coefficients, which are fairly uniform. The relative position of the cone does not greatly modify the efficiency of distribution, although an increase in the distance between the upper and lower cone improves distribution by throwing the outer cone of liquid further out and separating it more distinctly from the inner one.

In all cases, however, there is more or less fusion of the two cones of spray, and the tests showed a single zone of excessive discharge, not near the periphery of the wetted area, as with the Columbus nozzle, but about a third or a half of the way out from the centre of the wetted circle. The crude coefficients at 4.3-ft. and 6.4-ft. heads were a little higher than those obtained with the Columbus nozzle, averaging a little over 0.6 for the lower and about 0.7 for the higher head. The wetted area with this nozzle is, however, small for its high rate of discharge. The largest circles wetted were 11 ft. in diameter, and this was at rates of about 10 gal. per minute, corresponding to distances of 18 ft. between sprinklers. The corrected coefficients are therefore low, the best of them being barely over 0.2.

Efficiency of Pressure Distributors with Varying Heads.—With a sprinkler which, like many pressure nozzles, discharges in a conical sheet and forms an excessive discharge on a peripheral zone, it would seem to be of advantage to vary the head-on-sprinkler in such a way as to cause the zone of excessive discharge to travel in and out over the wetted area. This may easily be done by the interposition of siphon tanks in the supply system, and such is the practice at many English plants. It is clear that such varying heads must tend to improve the efficiency of devices like the Columbus sprinkler. Just how much improvement is effected under such conditions can, however, only be determined by exact measurement. Messrs. Winslow, Phelps, Story and McRae have therefore made a study of the operation of the Columbus sprinkler at varying heads, and the results have proved of considerable interest. They used a maximum head of 4 ft. (in two cases 3.7 ft.) and a varying minimum head from 3.5 down to 2 ft. The discharge was made from a square siphon tank equipped with float valves so as to start and cut off sharply. The time of filling this tank varied from 37 seconds to 3 minutes and 48 seconds, and the time of its discharge from 27 seconds to 2 minutes and 47 seconds. The rate in all cases was in the neighborhood of 4 gal. per minute. It was somewhat higher than this is some tests, but the wetted area was in all cases a circle of 10 to 10.5 ft. diameter, and the rates corresponded with sufficient closeness to a spacing of nozzles 11 ft. apart.

It was expected that a varying head would give more even distribution within the wetted area; and to the eye the waxing and waning cone of spray looks well-nigh perfect. Nothing could better illustrate the importance of the rigorous method of measurement adopted in these experiments. The crude coefficients are distinctly poorer with varying than with constant heads. An inspection of the original measurements shows the presence of a well-marked zone of excessive discharge just as in the case of the constant head, only not so far out from the centre of the wetted area. The smaller radial distance of this maximum zone accounts for its greater effect in reducing the coefficient.

On the other hand, the corrected coefficients were much improved by the intermittent operation. The wetted area was as great as in the tests at a constant head of 4 ft. and the discharge was much less. The average rate was as low as 4 gal. per minute per sprinkler. Therefore, for a total rate of 2,000,000 gal. per acre the nozzles could be placed much closer than at a 4-ft. constant head (11 ft. instead of 19), and the wetted area made to approximate more nearly to the tributary spares. Thus the corrected coefficients for a head varying from 4 ft. down range from 0.3 to 0.4 against a little over 0.2 for the constant head of 4.3 ft.

Taking the maximum heads of 4 ft., the evenness of distribution within the wetted area is better when the tank is not too long in emptying, since the crude coefficients are better with a minimum head of 3 ft. and over than with lesser ones. As the minimum head is increased, the corrected coefficient rises still more rapidly, increasing progressively from 0.30 to 0.43. This is because the wetted area at 3.2 ft. and 3.5 ft. minimum heads was somewhat larger than with a lower minimum, while the evenness of distribution was as good as at a 3-ft. minimum head. Evidently the best siphon tank is one with a short range of level which will discharge a small volume of sewage at frequent intervals.

Comparative Efficiency of Various Distributors.—The optimum conditions for distributors of various types have been somewhat fully discussed, but a brief comparative summary of their performance may be of interest. The results under optimum conditions (4-ft. total head for Birmingham, 6-ft. for the others) are summarized in the accompanying table.

COMPARATIVE EFFICIENCY OF DISTRIBUTORS OF VARIOUS TYPES.

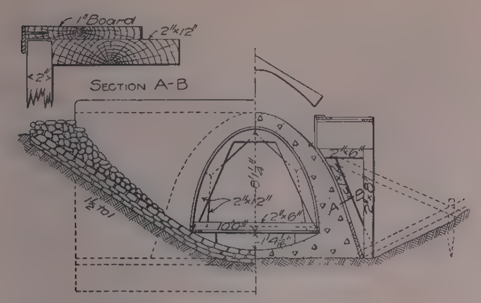
Type.	Rate, Gallons per Minute.	Crude Coefficient.	Corrected Coefficient.	Sprinklers per Acre to Discharge 2,000,000 Gal. per Day.
Best gravity distributor...	4.08	0.76	0.62	341
Old Salford	2.9	0.44	0.41	483
New Salford	2.1	0.78	0.67	667
Birmingham	2.0	0.80	0.80	700
Columbus	14.8	0.61	0.30	94
Waterbury	10.4	0.73	0.22	134

The American pressure nozzles, judged on the basis of these measurements, show a low efficiency in distribution. They cover the wetted area fairly well under the best conditions, but their discharge is so excessive that at a total rate of 2,000,000 gal. per acre they leave large waste areas between, and their corrected coefficients are correspondingly low. It must, of cours, be remembered that at a rate of 4,000,000 gal. per acre, for which the Columbus nozzle at least is designed, the corrected coefficients would be much higher. Furthermore, the performance of these nozzles may be further improved by the use of varying head, which increases a coefficient of 0.2 (for 4-ft. total head) to 0.4 (for a head varying between 3.5 ft. and 4 ft.) This question of varying heads well deserves further study, especially in the light of Mr. W. G. Taylor's plan for parabolic variations. The Columbus nozzle offers great advantages in the simplicity of its construction and in its large orifice if its excessive discharge can be overcome by the use of siphon tanks.

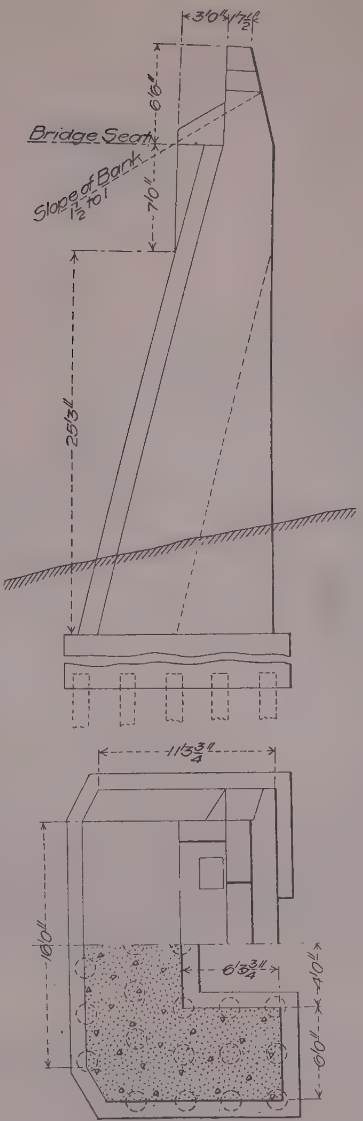
The best of the gravity distributors (a 3-in. metal disk with a 2-in. radius of curvature) has given much better results than had been expected. Without the complication of siphon tanks and varying head, it shows a corrected coefficient of 0.62, double that obtained for the Waterbury and Columbus nozzles under the same conditions. With a 4-ft. total head its coefficient is 0.40, while the Columbus nozzles gives 0.22 with a similar constant head, and the best Columbus nozzle value with a varying head is only 0.43. The smallest opening for clogging in the gravity system is the discharge pipe, ¾ in. in diameter, while the diameter of the Columbus nozzle is 9/16 in. Furthermore, the accessibility of the whole distribution system makes maintenance in good condition easy.

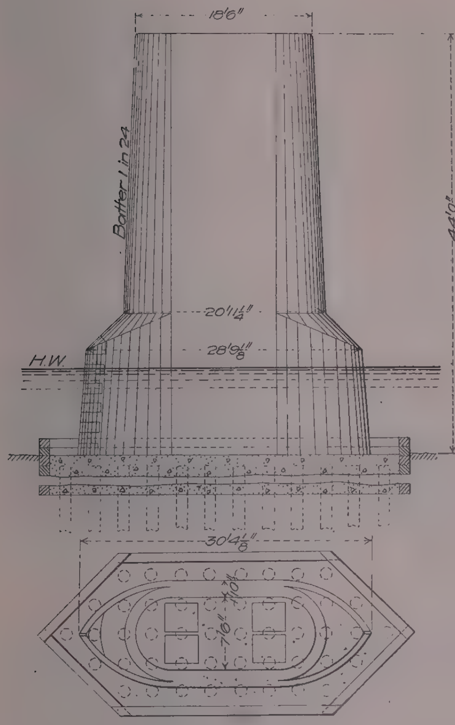
The new Salford and Birmingham pressure nozzles produce the most efficient distribution of any of the devices tested. At a 6-ft. total head the Birmingham coefficient is 0.69, and at a 4-ft. total head it is still better (0.80), the distribution being almost perfect. These good results are, however, gained by the use of nozzles which are extremely liable to clogging. The openings of the new Salford nozzle are only 5/32 in. in diameter, and the cone into which they discharge is admirably adapted to collect solid materials. The opening in the Birmingham nozzle is a ring only, 5/64 in. in diameter. Its removable plug indicates that even with the carefully screened and septicized sewage of Birmingham it requires frequent attention; and it is difficult to see how any such device could be economically used under American conditions, even with septic sewage. On the other hand, crude sewage can be sprayed by the Columbus nozzle or the gravity distributor without difficulty from clogging.

A POWER SHUTDOWN at the Edgemere Mills, Great Barrington, Mass., was caused recently by water bugs entering the push-button of the engine-stop, producing a short-circuit and consequent stop.

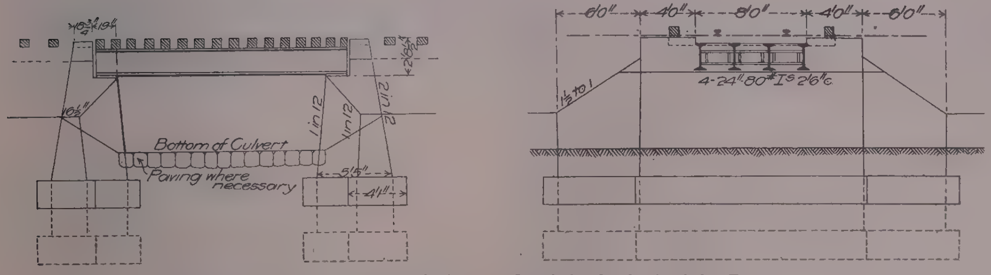


Standard Concrete Culvert.





Pier and Abutment, Grand River Bridge.



Standard I-Beam Culvert, Guelph & Goderich Ry.

Lower Maitland Bridge during Construction, Guelph & Goderich Ry.

Construction of the Guelph & Goderich Railway.

By J. Grant MacGregor, Assoc. M. Am. Soc. C. E.

A charter for the construction of a line from Guelph to Goderich in the Province of Ontario was granted in 1884, but it was not until September, 1904, that the present company, under the auspices of the Canadian Pacific Railway Co., began construction. The limits of grade and curvature were fixed by rules and diagrams issued by the Canadian Pacific Ry. for the use of velocity grades wherever practicable, such limitations being based on experiments made on an extensive scale by the Northern Pacific Ry., and from which the diagrams referred to had been prepared. The application of the velocity grade diagrams to the original grade profiles eliminated much heavy work and established on an economic basis a virtual 0.60 per cent. profile for eastbound traffic, for a minimum speed of 10 miles per hour, the train load assumed being 1,631 tons. The only exception was a one per cent. helper grade for the first 6 miles eastbound from Goderich. In extreme cases the above limitations may have been exceeded, depending, perhaps, on an increased acceleration to overcome some of the higher summits.

In order that the effect in such cases could be determined, the diagram had to be abandoned and the usual theoretical rule substituted. This led the writer to compare the data obtained by experiment with the results obtained by theory in expectation of being able to modify the 0.60 per cent. and 10 mile per hour requirement to embrace the new conditions, but he was unable to do so with the class of locomotives expected to be put in operation on the division. This requirement had, therefore, to be departed from in some cases, reducing the speed at summits to six miles per hour and even lower. The velocity heads shown on speed diagram are substantially those given in table 118 of Wellington's "Railway Location," and are derived from the formula for finding force of gravity in falling bodies, $h = v^2/2g$, to which is added 6.14 per cent. for the rotative energy stored in the wheels. As stated elsewhere, the writer is inclined to attach very little importance to the so-called potential energy stored in the wheels of a moving train and doubts if such force has any value in addition to the momentum of a train in its ascent or descent upon a grade. It is evident that the greatest speed of the wheel is at its point of contact with the rail, and is no greater than the speed of the train, the centrifugal force in the wheel itself being dependent on and maintained uniformly with the momentum of the train throughout its entire movement. On this account and for other reasons the factor for potential energy has invariably been omitted from formulas for velocity grades, the result being a closer approximation to velocities obtained from actual experiments.

The distance from Guelph to Goderich is 80 miles, and with the exception of 20 miles at the Goderich end the location presented but few difficult engineering problems. The location of the last 20 miles, however, was repeatedly revised, leaving no doubt as to the final location being the most favorable.

The average quantity of earthwork in the first 60 miles was 18,300 cu. yd. per mile, that of the last 20 miles 42,000 cu. yd. per mile approximately. No rock had been encountered throughout the whole line. The classifications specified were "solid rock," "loose rock" and "common excavation," the latter embracing all materials which could not be classed as loose rock. To avoid disputes and simplify questions arising from the calculation of overhaul, the usual clause was annulled, and a fixed amount included in the contractor's tender to cover the cost of all overhaul, such amount being previously determined by estimating the extra cost of removing from the line excavation the quantity in gutters of sufficient width to permit of the additional widening being done by train haul. Earthwork was paid for by quantities measured in excavation. The rate of shrinkage observed in embankments was from 5 to 8 per cent., the material being almost uniformly a clayey gravel where observations for shrinkage were made.

The structures are absolutely of a permanent character and are built entirely of concrete, the only exception being the upstream cutwaters of the piers of large bridges, which were faced with cut stones. Except overhead bridges at two places, there are no wooden bridges or culverts on the whole line. Concrete pipe culverts were used up to 24-in diameter, and concrete arch culverts from 5 ft. to 10 ft. diameter, also concrete rail culverts up to 10 ft. clear span in low embankments. For greater spans than 10 ft. in low embankments, I-beam spans with concrete abutments were used. The proportions of concrete used were for piers and abutments 1:4:7 and for arch culverts and foundations under water 1:3:5. There was no difficulty in procuring good gravel for concrete, and frequent tests were made in order that the correct proportion of sand could be added before mixing.

In the designing of piers and abutments, the standard designs of the Canadian Pacific Railway were adhered to as closely as circumstances would permit. The graceful form of the piers of the larger structures was evolved from the application of the gothic shaped cutwaters, it being found that a circular end above the cutwater base permitted a shorter base than would be required if the radii of the cutwater had to be struck from the corners of a rectangular pier of equal dimensions at the bridge seat. According to Cresy's experiments this form of cutwater is as near as practicable the one which offers least resistance to the current, in addition to being a more massive form for concrete work where exposed to the erosion of drift and ice.

There are altogether 29 bridges with steel superstructures, and although four of them are of considerable magnitude, there are no lattice spans —plate girders being used exclusively up to 110 ft. length. The four larger bridges worthy of note are the Grand River and Conestoga River crossings, and two crossings of the River Maitland. The Grand River bridge consists of three 100-ft. and two 50-ft. spans, the Conestoga River bridge of four 105-ft. spans all being deck plate girders. The upper crossing of the River Maitland consists of three 105-ft. through plate-girder spans. The lower crossing of the River Maitland near the town of Goderich is spanned by five 105-ft. and two 85-ft. deck plate girders, the total length of structure being 720 ft. and height 60 ft. above low water. In the construction of this last bridge, 3,500 cu. yd. of concrete were employed, and 1,007,600 lb. of steel. A glance at the view of the Lower Maitland bridge will enable the reader to judge of the substantial character of the work.

The entire road is laid with 80-lb. rails and excellent ballast was easily procured at convenient intervals along the line.

The station buildings and terminals are also in conformity with the character of the work already described. The railway was formally opened for traffic to Goderich on Sept. 12, 1907, three years from the date of the turning of the first sod, and although this appears to be an unusually long time in which to build 80 miles of line, the permanent character of the work must be taken into account, together with the severe winter and the heavy work at the Goderich end, across the valley of the Maitland River. This last mile alone consisted of 10,450 cu. yd. of concrete in bridges and retaining walls, and 265,000 cu. yd. of earth excavation.

The whole work was carried out under the direction of Mr. P. A. Peterson as chief engineer, Mr. J. W. Leonard being president of the company. The organization of the engineering staff consisted of an assistant or office engineer at headquarters, one division engineer and two residencies for each 20 miles of line.

Motor-Driven Rolling Mills are to be installed at the new plant of the Buffalo Copper & Brass Rolling Mills, at Black Rock Station, N. Y. For driving the rolls, three Allis-Chalmers induction motors will be used, one of 500 h.-p. for the main rolls and two of 250 h.-p. for the finishing rolls. All three motors are of the wound-rotor type, designed to operate at 25 cycles, 2,300 volts; the 500-h.-p. motor runs at 375 r.p.m., synchronous speed, and the 230-h.-p. at 500 r.p.m. The motors are connected to the rolls by means of flexible couplings. Power will be transmitted from Niagara. Mr. B. J. Dashiells is consulting engineer in charge of the new construction and equipment, which will be used chiefly in the manufacture of copper sheets.

The Stadium of Syracuse University.

There has lately been completed at Syracuse University, Syracuse, N. Y., a reinforced concrete stadium for athletic games, which has a normal seating capacity of 20,000, and covers 6⅓ acres. Its magnitude can be judged by some of the dimensions and quantities. The length is 670, the width 475 ft., and the construction required 250,000 cu. yd. of excavation, and the use of 20,000 cu. yd. of concrete and 500 tons of reinforcing steel. The work has been done by the Consolidated Engineering & Construction Co., of Syracuse and New York, and the following notes concerning it are taken by permission from advance sheets of an elaborate copyrighted report on the design and construction, which will be issued by the company in a short time.

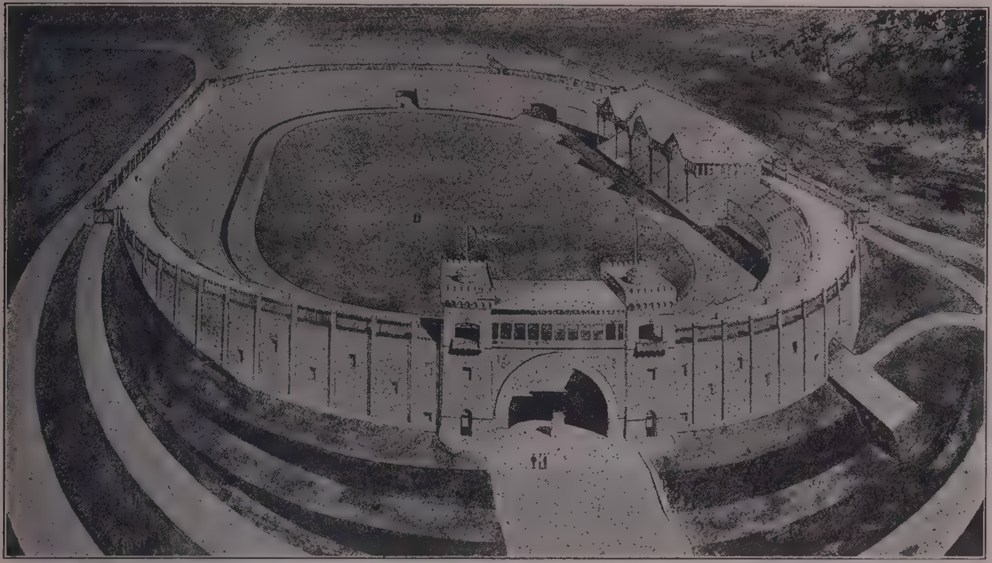
The grounds of Syracuse University contain a number of hills, and in one of the hollows, in the west side of the campus, the new Stadium has been erected. In plan it forms an oval, with semicircular ends, joined by a straight part 198 ft. in length. The central part of the field, intended for foot-ball games, is covered with sod. Outside of this sodded part is a running track one-quarter of a mile long.

In order to insure a good view of the races from every seat, the track does not come close to the structure, but is separated from it by a space 5 ft. wide. Immediately outside of this space is a concrete wall 5 ft. high, the top of which forms a curb for a 4 ft. walk, which runs around the structure, 4 ft. 6 in. above the field. Above this walk rise eighteen tiers of seats, 18 in. high and 27 in. wide, to a level 31 ft. 6 in. above the field. At intervals of 30 or 35 ft. small steps 2 ft. long, 13½ in. wide and 9 in. high have been built on top of the seats to form stairs. At the top of the seats is a concrete wall 12 in. thick and 3 ft. 6 in. high. Opposite every row of steps this wall has an opening 4 ft. wide. Outside of the wall is a promenade 20 ft. wide, covered with asphalt. It is surrounded by a curb 2 ft. wide on which rises an iron fence 8 ft. high, between concrete posts about 18 ft. apart. The rear of the concrete work is covered entirely by the ground which runs up to the level of the promenade, except at the west end, where it falls off suddenly to a level 35 ft. below the promenade. The stadium here has curtain walls and piers of reinforced concrete and is surmounted by two towers. From both sides of the main entrance, inside the arches, stairs run up to the promenade, and from

General Views of the Stadium of Syracuse University during Construction.

this point the people are distributed to the various sections of the structure by way of the promenade.

The grand stand occupies the whole straight part of the south side of the structure, 196 ft. in length. It is covered by a cement roof, supported by steel trusses and columns, and suggests in design the Gothic style of architecture. On both sides of the grand stand for some distance the ten lower tiers of seats are omitted and a retaining wall 20 ft. high forms the interior part of the concrete work. This arrangement was made in order to obtain a straight track for 220 yd races, which made it necessary to build two tunnels, through which the track continues outside the stadium proper. At the east end, still another tunnel connects with the new Gymnasium, now under construction.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View of Completed Stadium of Syracuse University.

On account of the topography of the campus special attention was paid to the drainage. For this purpose the promenade at the top, and the walk at the bottom of the seats were graded towards outlets about 50 ft. apart. These were connected with 4 in. cast iron pipe which carried the water to the sewer. Throughout the field in different directions ditches were formed, on the bottom of which were placed open tile drains leading to the sewer. The tile was covered with broken stone, on top of which the sod was placed. For the running track, drainage was provided by a foundation of broken stone, which is covered with a layer of cinders. During the fall several heavy rain storms have occurred which have afforded a good test for the drainage arrangements, and after each rain the field has dried out in a short time. A sprinkler system has also been installed. This consist of water pipe running through the longitudinal axis of the stadium, branching off to both sides, so as to form outlets near the edge of the sodded foot-ball ground at distances of about 100 ft. These outlets can be connected with hose for sprinkling the field or flushing the seats.

Construction of Seats Showing Part of Forms in Place.

In regard to the design of the concrete work, the whole superstructure is carried on piers which are placed five in a row. These lines of columns are spaced 15 or 16 ft. apart for the straight portions, and at distances occupying 4 deg. 30 min. for the curved ends. A large part of the banks has been formed by a filling of loose earth. In such cases the piers have been carried down to the original soil; where no fill existed, they have been brought down 4 ft. 6 in. below the surface. The ground consists in different places of hard pan, gravel, sand or loam. The footings, which are of concrete without reinforcement, are proportioned for a load on the soil varying from one to four tons per square foot.

The size of the columns was governed by conditions apart from the unit stresses adopted. In general they were made of uniform size, of rectangular shape, 12x30 in., reinforced with four Kahn bars, weighing 2.7 lb. per foot. The rectangular shape was adopted in order to resist the effect of any sliding tendency that the bank might have. Where it was necessary to use columns of great length, they were made square, with a side not less than 1-15 of the length of the column, reinforced with four ⅞-in. rods, and wrapped with Clinton wire cloth 3x8-in. mesh, 8-10 wire. In general all parts of the structure were figured for a live load of 100 lb. per square foot, except the promenade, which was designed for 120 lb., and the roofs over the grand stand and main entrance, which were figured for a live load of 40 lb. per square foot.

In calculating bending stresses, the straight line formula was used throughout, and the tensile strength of the concrete was neglected. The safe compression stress for concrete was assumed to be 600 lb. per square inch and the safe tensile stress for steel 16,000 lb. per square inch. The girders, steps, and the slab of the promenade were figured continuous and the maximum bending moment was assumed to be $WL \div 12$ where W represents the total dead and live load and L the distance between supports. The negative bending moment over the supports was assumed to be $WL \div 18$ and steel was provided according to this assumption. The main girders are 2 ft. deep and 1 ft. wide. The slab formed by the steps has a minimum thickness of 4 in. and the slab of the promenade a thickness varying from 7 to 9 in., depending upon length of span. This design for the promenade was adopted in order to make it possible to remove the forms, which would have been impossible if ribbed construction had been employed.

The main reinforcement for girders, steps and promenade consists of Kahn bars, with stirrups varying in length from 6 to 30 in. In addition to the Kahn steel, Clinton wire cloth has been placed 1½ in. below the surface of all concrete exposed to view. This was done solely to prevent cracking, and the wire cloth was not taken into consideration when figuring the bearing capacity of the concrete. The sizes used were 4x6 in. mesh 10-10 wire, 30 in. wide, for the steps and 3x8-in. mesh, 8-10 wire, 72 in. wide, for other places.

In order to prevent cracks due to temperature changes, contraction joints should not be placed farther apart than 25 or 30 ft. At the Syracuse stadium joints spaced at such a short distance would have seriously interfered with the construction, caused unnecessary additional expense, and would besides have been quite as objectionable in appearance as promiscuous cracking. It was therefore decided not to leave any contraction joints, but an endeavor has been made to prevent cracking as much as possible by using a sufficient amount of reinforcing steel.

In order to decide the quantity of steel required, assume that the area in cross section of concrete is A square inches, the area of the steel A', the coefficient of expansion for concrete and steel 0.0000055 and 0.0000065 respectively, the modulus of the elasticity of the steel 30,000,000 lb. per square inch, and the elastic limit of the steel

50,000 lb. per square inch. A temperature fall of 100° would cause a proportionate contraction of the concrete of 0.00055, which is far more than plain concrete could be stretched. If reinforced, it could easily be stretched this amount, and the stress caused would then equal the breaking stress of concrete. If the tensile strength of concrete is 300 lb. per square inch, and if we assume that the whole stress in the concrete is transmitted to the steel, the stress caused in the steel is $300\ A/A'$. Through the fall of temperature in the steel itself a tensile stress of $100 \times 0.0000065 \times 30{,}000{,}000 = 19{,}500$ lb. per square inch is caused. Therefore:

$$300\ A/A' + 19{,}500 = 50{,}000.$$

The equation gives the proportion of steel to concrete as 1 per cent.

Experiments seem to prove that reinforced concrete retains its full tensile strength even for very considerable deformation. It would therefore be reasonable to assume that only a part of the stresses caused by the cooling of the concrete are transferred to the steel. Allowing that ⅔ of the stresses are taken by the concrete itself, the proportion of steel required would be one-third of one per cent. In the design of the Syracuse stadium an effort has been made to keep the percentage of steel above this figure. To insure continuity of the reinforcement, all bars in the seats and promenade are 2 ft. longer than the span. A further precaution against cracking is the wire cloth running around the whole structure below all exposed surfaces.

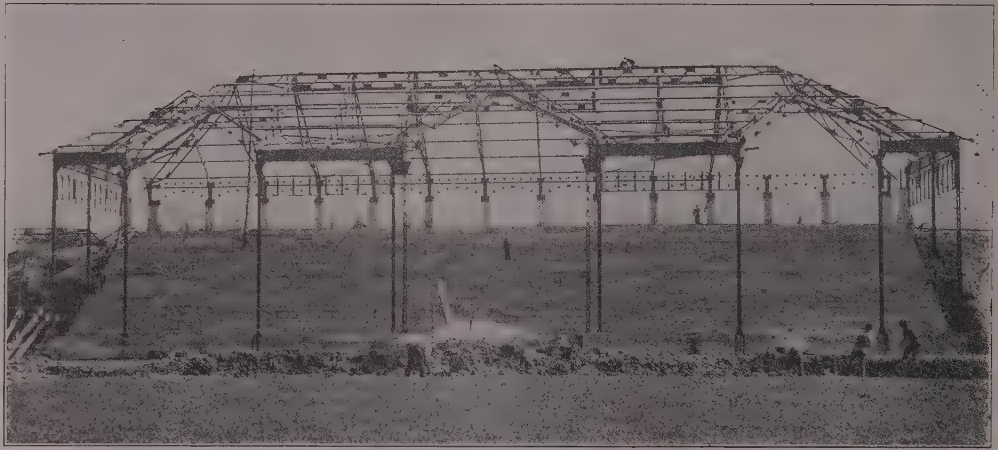
On account of the nature of the surface treatment, it was impracticable to use wire cloth near the surface of the walls on the west side of the structure. Instead, ¾ in. steel rods spaced vertically 2 ft. apart, and horizontally 18 in. apart, were placed in the centre of the walls.

The main entrance consists of concrete stairs and platforms, which are carried on girders and columns. The towers contain the ticket offices on the ground floor. At a higher level are located offices for the managers of the teams. Directly over the main entrance at the level of the promenade the floor is of tile and concrete construction, the tile being 8 in. deep and 12 in. wide, and spaced 16 in. apart, so as to form concrete beams 4 in. in width. Each one of these concrete beams is reinforced with a 4.8 lb. Kahn bar. On the top of the 8 in. tile is a layer of concrete 3 in. thick, making the whole floor construction 11 in. In order to prevent cracking the concrete slab is reinforced with ½ in. steel rods placed 6 in. center to center, and perpendicular to the Kahn bars.

The roof of the grand stand is of cement, reinforced with ferrolithic plates. These consist of steel sheets, 24 gauge, corrugated to a depth of ¾ in. so as to form dovetail grooves. At right angles to these dovetail corrugations, the steel sheets have some lighter corrugations about ⅛ in. deep. The ferrolithic sheets are attached with clips to the purlins, which consist of 6 in. I-beams, spaced about 6 ft. 10 in. apart. The roof construction is formed by steel trusses of the type known as "French" trusses. At the right and bottom, the main trusses are joined by lattice and plate girders which carry intermediate trusses. From the top of the two end trusses project cantilever girders which serve to carry the four trussed hips.

For the circular and Gothic arches immediately below the roof, a framework of light steel angles has been used. This steel work has been furred with small steel channels and bars, covered with metal lath and plastered with cement. The roof structure is supported by steel columns in the front and sides, but in the rear, the trusses come down directly upon the concrete piers. The columns are made of four 3½x3-in. angles, and covered with concrete. In the center of the columns are located 4-in. cast iron leaders which carry the water from the roof. In figuring the columns the steel was calculated to take all loads.

The two tunnels for the straightaway at the east and west ends of the building go through the retaining walls at an angle of 37 deg., and form openings in the same about 34 ft. wide. The tunnels which are symmetrical in their design, have a width of 20 ft. and a height on the center line of 14 ft. The walls of the tunnels are 2 ft. thick, reinforced with 1.4 lb. bars, placed near the inside, 6 in. center to center. Below the ground they are braced against each other by four concrete beams 15 x 18 in., reinforced with one ⅞-in. round steel rod in the center. The concrete arch forming the roof of the tunnel has a rise of 3 ft. and a thickness at the crown of 15 in. The reinforcement consists of wire cloth. Three feet from the outside ends of the tunnels a pocket is left in the roof and walls in which is placed a Kinnear rolling steel shutter. The tunnel leading to the new gymnasium is located in the east end at the longitudinal axis of the stadium. It has a width of 20 ft. and a height in the center of 14 ft. Above the tunnel on the curve at the foot of the seats is to be placed a brass railing 3 ft. high. This will return down the edges of the steps where an opening is formed in the concrete work. A similar railing is to be placed on the curve above the retaining walls and in other parts of the structure where the height above the ground makes it necessary. A smaller brass railing 2 ft. high will run on the curb at the foot of the seats on top of the 5 ft. breast wall.


Steel Frame for the Grand Stand.

On the outer edge of the promenade surrounding the structure are located ornamental posts from 15 to 19 ft. center to center. In about every third post an electric conduit is incased for an arc light. On all the other concrete posts brass pins have been imbedded for carrying pennants. Between these concrete posts is an iron fence about 8 ft. high.

At the center of the curved east end two sections of the fence are omitted, as it is the intention to connect the promenade at this point with the new gymnasium building.

The work for the stadium was started by Syracuse University without the aid of any contractor, and a considerable amount of excavation was done on this arrangement. The earth was loosened and then brought, by wheel and drag scrapers over a temporary wooden bridge provided with a hopper, through which it was dropped into dump wagons.

When, however, the contract for the completion of the excavation and for the construction was awarded to the Consolidated Engineering & Construction Co., it was decided to make different arrangements for getting out the materials and eliminating delays. A large derrick was erected on the top of the bank at the north of the hollow, and an industrial track, 24-in. gauge, was run from the derrick, on a trestle, to a point on the campus, a distance of about 500 or 600 ft. to the north.

In the hollow, directly below the derrick, within boom reach, similar tracks were laid to the different places where excavation was to be carried on. The earth was placed in steel double dump cars on the industrial track and were lifted by the derrick out of the hole and placed on the trestle above, from which point the cars of excavated material were hauled by horses and trains to the point where the material was to be dumped. At intervals, switches were placed in the track so that the cars could pass in different directions. The derrick used was a steel lattice derrick with a 70-ft. mast, having a capacity of 8 tons. A Ransome concrete mixer was also placed within boom distance of this derrick, on top of the bank, and the same derrick was able to pick up a car of concrete and lower it into the hole onto the tracks, from which place it was pushed to the various locations for building the concrete foundations. The industrial tracks also ran from this concrete mixer around the top of the bank where the promenade is now located, and by this arrangement, a carload of concrete could be quickly delivered at either the top or at the bottom of the bank, at any point on the structure.

On the bank above the retaining wall, at the southeast corner of the structure, where a very heavy cut occurred, another large steel derrick was placed for hoisting carloads of excavated material to a trestle on the upland, from which point these cars ran by gravity into the valley where the material was dumped. The cars then returned empty, by gravity, on tracks directly on the ground to the foot of the derrick. Another Ransome steam concrete mixer was located within boom distance of this derrick, and the tracks were arranged so that the car of concrete could be placed by this derrick on the tracks down at the level of the field or up at the level of the promenade, from which point the concrete was quickly and economically distributed. This last mentioned derrick had a 75-ft. boom, and a capacity of 9 tons.

The lumber used in general for forms was hemlock and pine, the sizes consisting largely of 1 x 6, 1 x 8, 2 x 4, 2 x 8 and 2 x 10-in. For the round concrete columns, the forms were made of 2 x 2 or 2 x 3-in. pine, dove-tailed and held together by iron bands. These circular forms were corrugated on the inside for the purpose of giving a better hold to the cement finish.

The forms for girders supporting the seats were made of 1-in. material braced by a frame of 2 x 4-in. about 2 ft. apart. It was necessary to cover the upper side of the girders on account of their slope in order not to interfere with the tamping of the concrete. This was done in the following manner: For every batch of concrete filled into the girders a few pieces of 1 x 6-in. were nailed to the upper side of the girder. These pieces were not put close together but placed at a distance of about ½-in. Large spikes were placed in these pieces in order to give good bond between the girders and the seat slab that rested on top. The supporting forms of the promenade and the seats were made of 1-in. matched stock on 2 x 4-in. supports. Wherever possibe they were built in sections and used over again six to eight times. The forms for the risers were made of 2-in. stock. Steel wire was used for keeping forms from spreading. The concrete work is 1:3:5 for the plain concrete and 1:2:4 for the reinforced concrete.

The stone consisted mostly of limestone, for plain concrete broken to pass a 2-in. ring, and for reinforced work to pass a ¾-in. ring. All concrete was mixed very wet, and very thorough stirring was necessary to get the forms properly filled, particularly where wire cloth was used.

Movable Sheds for Protecting Cement Finishing from the Sun.

All concrete was mixed with machinery. The plant for mixing consisted of five Ransome mixers with engines and boilers, and a small Smith mixer on wheels was used as an auxiliary. All the mixers except the one near the main entrance were located at the top of the bank.

The surfaces are finished by plastering after the removal of the forms. To obtain a good bond between the plaster and the concrete special means have been employed. At frequent intervals wire nails were driven into the forms on the inside so that the pointed ends projected about 2-in. outside of the rough concrete after the forms were removed. Before applying the plaster a small iron nut was put on each projecting nail; the concrete work was then covered with wire lath, and the nails bent over it with the blow of a hammer. The nuts serve to keep the wire lath at a distance of about ¼ in. from the old concrete. The wire lath used was 2½ meshes to the inch and No. 20 wire. The nails were about 4 in. long, with a bend of ¾ in. at one end. The nuts were either square or hexagonal, about ¼ in. high.

The plaster was put on in two coats, with a total thickness varying from ¾ to 2 in. The scratch coat was composed of 1 part cement, ¾ part lime, and 3 parts sand. The finishing coat, which is about 3-16 in. thick, is composed of 1 part cement, to 1¾ parts of sand. The sand used in the finish is white beach sand from Long Island.

To carry the plaster to the desired lines iron templates were placed at intervals, and the plastering finished to them. Before the finishing coat had commenced hardening the templates were removed, and the void left by them filled in. The second coat of plaster was put on when the scratch coat commenced hardening, and was troweled to a smooth finish.

While the cement finishing was being executed the work was protected from the sun by wooden sheds, which were erected over it and moved according to the progress of the work. During the hardening of the plaster it was covered with burlap, on top of which a layer of sand, which was continually kept wet, was placed.

Where the concrete work is of an ornamental character the outlines of the ornaments were followed by the rough concrete and it was afterwards finished by plastering on wire lath attached to the body of rough concrete in a similar manner as for ordinary work. The only case where a different procedure was followed was for the capitals at the steel columns of the grand stand. These were moulded in four parts and put together round the columns with copper wire. The shaft of the columns was made of solid concrete enclosing the steel and finished by plastering on wire lath. To keep the wire lath from the rough concrete this was made corrugated and the lath wrapped around.

The upper side of the ferrolithic covering of the grand stand was coated with a mixture of one part of Portland cement to three parts of clean sharp sand. The sand and cement were mixed dry. The thickness of the coating above the top of the corrugation is 1¼ in. The entire coating was put on in one mass, without the use of a scratch coat. The surface was roughly floated, and the corrugations were thoroughly cleaned before the concrete was applied.

The underside of the roof was coated with a mixture of 1 part of Portland cement, ¾ parts of hydrated lime, measured dry, 3 parts of sand and a little hair. One pound of hair, weighed dry was used, for every batch of 25 cu. ft. of concrete.

The general contract was awarded in Sept., 1906. During the winter of 1906 the work was shut down on account of the cold weather and started up again in the spring of 1907. The last of the reinforced concrete work was put in place Oct. 22, 1907, making the working time about 10 months.

The architects were: Professors Revels and Hallenbeck, of Syracuse University.

The Extension of Keyham Dockyard.

The extension of the Keyham dockyard at Devonport is one of the more important British engineering achievements of recent years, and some of its leading features can be understood from a paper on the subject presented last month before the Institution of Civil Engineers by Sir Whately Eliot. The dockyard extension occupies an area of 118 acres, of which 77 acres were mud foreshore. The works consist of three graving-docks, two of them opening into a tidal basin of 10 acres at the south end, and all of them opening into a closed basin of 35½ acres at the north end, also of a lock giving access to the closed basin. A retaining wall has been built along the east boundary of the new works which adjoin higher ground. The whole area of the works was enclosed on the water side by a coffer-dam 5,576 ft. in length, which entirely excluded the tidal water. Portions of the works situated landward of high-water line were commenced while the coffer-dam was being constructed.

The tidal basin walls are everywhere founded on rock, the depth varying from 57 to 80 ft. below the coping, and the bottom of the basin being 55 ft. below coping. The walls are constructed of concrete, the upper part faced with granite. The face of the wall is formed to a batter of 1 in 8 in the upper part, in the lower part to a batter of 1 in 4, the two parts being joined by a curve of 135 ft. radius. On the west side is the entrance, 120 ft. wide. Timber fendering is fixed to the upper part of the walls.

The closed basin is 35½ acres in extent, including the pier, and the formation of the walls is practically the same as for the tidal basin. The height of the walls from foundation to coping varied from 57½ to 108 ft.; the bottom of the basin is 55½ ft. below coping, and 32½ ft. below low water of spring tides. From the center of the north wall a pier extends into the basin; this pier is 500 ft. long and 75 ft. wide. On the west side of the basin an entrance is constructed 95 ft. wide, with a depth on the sill of 32 ft. at low water of spring tides. The entrance is closed by a sliding caisson, and also by a floating caisson.

When the mud had been removed from the site of the docks, and the rock cut out to the form and depth required, concrete was deposited, the average depth under the center part of the floor being 14 ft., and under the side parts 12½ ft. The concrete was deposited in sections, and to the full depth, to avoid horizontal joints. The floor-stones of granite were bonded into the concrete and bedded in cement-mortar. After the concrete floor was completed, the side walls were commenced. Up to the level of the first broad altar, the beds of the granite face-stones radiate, the concrete at the back having been first deposited and shaped to receive the face-stones. In the upper part of the walls the face-stones were set on a level bed, and afterwards backed with concrete. The walls of the docks and lock above the top broad altar are faced with concrete blocks having a granolithic face.

Dock 4 is 650 ft. long, Dock 5 is 745 ft, Dock 6 is 741 ft., and the lock is 730 ft. long. All the entrances are 95 ft. wide, and fitted with sliding caissons. In Docks 5 and 6 a floating caisson is fitted into a groove dividing each dock into two separate docks, if required. The width of all the docks on the floor is 70 ft., and at the coping 121 ft. The lock is constructed so that it can be used at any time as a graving-dock. The depth of water at low water of springs on the sills of Docks 4 and 5 is 20½ ft., of Dock 6 and the lock 32 ft. The floor of each of the docks is 4½ ft. below the floor of the entrance.

The outer wall forms the west and north boundary of the new works, and extends from the south end of the lock to a point near the Naval Barracks. The total length of the wall is 4,730 ft.; it is founded throughout on rock. For half the length the depth of mud varied between 30 and 60 ft., and for the remaining half it varied between 60 and 100 ft. In order to reach the rock through such a depth of mud a special form of concrete column was used. These columns were built in rings 2½ ft. thick, the rings being in sections, and jointed with cement mortar. Three wells were formed in each column, through which excavating grabs worked, and brought up mud from the bottom of the column. The base of each column was provided with a cutting ring of concrete 5 ft. in depth, and formed in one piece, strengthened with iron bands embedded in the concrete. The ring was made in place, and when it was ready to be sunk, built-up rings were added, and the mud was lifted from the wells by grabs, weights being placed on the top of the column to force it through the mud. The columns were sunk until the rock was reached, which was then levelled by hand, and the wells were filled with concrete.

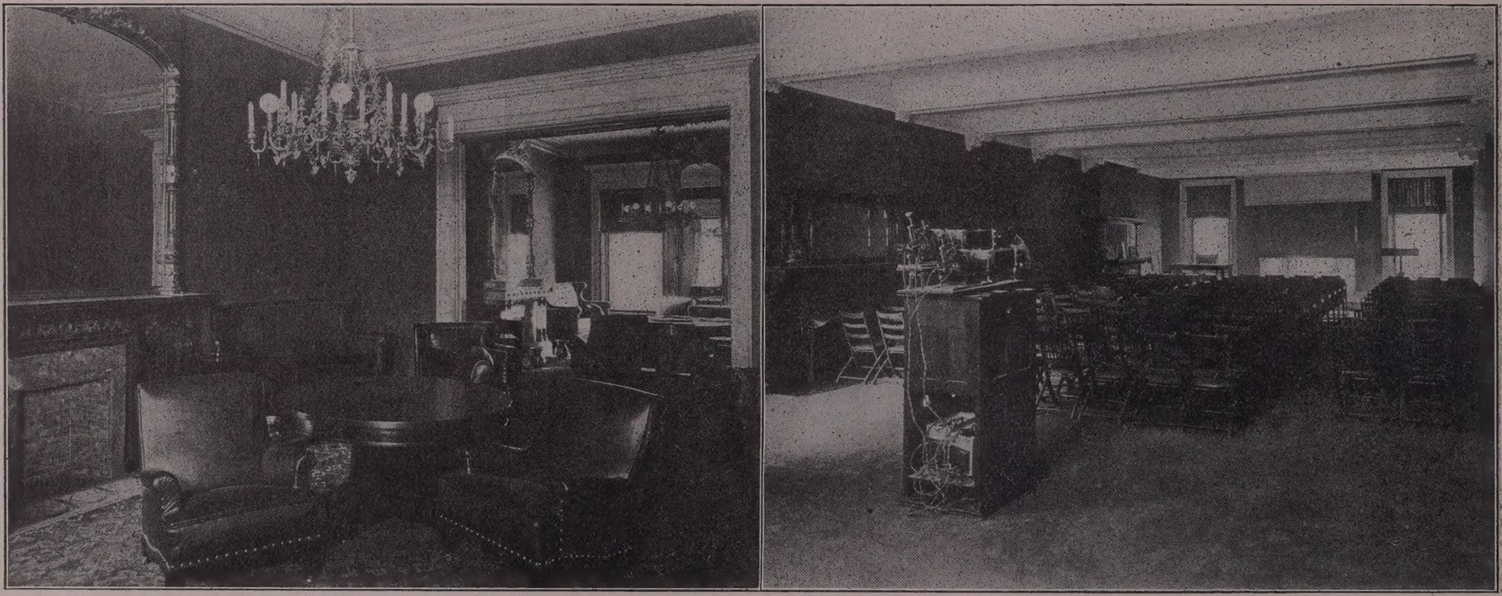
When the depth of mud did not exceed 60 ft., a single row of columns was sunk, and a timbered trench was excavated at the back, in which the back part of the foundation was constructed of concrete, which was packed around and between the columns, spaced 10 ft. apart. When the depth of mud exceeded 60 ft. it was necesary to sink a double row of columns, 3 ft. apart transversely. The spaces between the columns were then cleared of mud and filled with concrete. The sinking of the columns was carried out very successfully, and a solid foundation was obtained on which to build the upper wall, which is faced with concrete up to 26½ ft. below the coping, and above that level with granite, to which is attached a fendering of timber.

For filling the docks with water, two culverts, 8 ft. high and 6 ft. wide, are provided at each end, and fitted with penstocks. For emptying the docks two main culverts, 7 ft. in diameter, are provided, one at each end, and connected by branch culverts to the interior of the docks. The water is conducted by them to the main pumps.

BLOCK SIGNALS are now used on all the main lines of the Pennsylvania R. R. and on all but about 500 miles of the entire system east of Pittsburg and Erie. With the automatic system the annual operating expense is about one-twelfth of the first cost, while with the telegraphic system the annual operating expenses are about three-fourths of the first cost.

The New Home of the Engineers' Club of Philadelphia.

With hospitality in keeping with its thirty years' tradition, the Engineers' Club of Philadelphia threw open the doors of its handsome new $70,000 clubhouse on Saturday evening, Jan. 11. Men prominent in the engineering world, architects, builders, personages conspicuous in the management of great corporations and in politics took part in the house-warming, which marked as well, even if a trifle belated, the thirtieth anniversary of the club. The club was founded Dec. 17, 1877, and the celebration of the anniversary was deferred until the members could be initiated into the new home. As the guests arrived, they were received by President Henry H. Quimby, Vice-Presidents Washington Devereux and W. P. Dallett, Secretary Walter Loring Webb and Treasurer George T. Gwilliam, assisted by the Board of Directors and the president-elect, H. W. Spangler and the new officers. Among the prominent public men who attended were: Congressmen J. Hampton Moore, H. C. Loudenslager and George D. McCreary, District Attorney S. P. Rotan, Judge W. H. Staake; John W. Townsend, vice-president of the Cambria Steel Co.; Dr. W. P. Wilson, director of the Philadelphia Museum; C. C. Harrison, provost of the University of Pennsylvania, and E. T. Stotesbury, the well-known banker.



Lounging Rooms and Meeting Hall of the New Engineers' Club of Philadelphia.

The building, which is situated at 1317 Spruce St., was formerly the private residence of Charles W. Potts, an iron manufacturer, and was purchased by the club for $55,000. The Potts residence was always reputed to be one of the best appointed in Philadelphia, and the club found it so. Few, if any, repairs had to be made and the alterations were inconsiderable. Built of brown stone, four stories in height, with a frontage of 25 ft. and depth of 140 ft., the building presents a pleasing exterior, although it is the interior that appeals most to the members.

Entering a wide hallway, to the right is a double reading-room and reception room, 17 x 48 ft. This room is fitted with two notable mantel pieces, one of solid onyx of beautiful color, and the other of solid mahogany. The main chandelier in this room is of gold, made after an Oriental design, and imported from Turkey by Mr. Potts at the cost of more than $1,000. This room is easily the most sumptuous in the house, but the dining-room or cafe in the rear has its individual charms, with its Italian mosaic floor, large bay window, its walls covered with a quiet brown hand-made Japanese paper and its paneled mahogany ceiling. In the rear of the cafe, which is a room 20 x 30 ft., are a serving-room and kitchen where the steward or his assistants will be prepared to serve refreshments of some sort at all hours. The cafe is quite an innovation for the club.

Mounting a wide stairway, which is well lighted with odd Turkish chandeliers, and skirts an attractive brown stone and marble fireplace the visitor finds the club library to the rear. This room, 17 x 34 ft., is covered with cork carpet and filled with books of reference and bound copies of the club's "Proceedings."

In the front section, two rooms have been converted into a 24x48-ft. meeting hall. Here 200 members can be seated and it is the intention of the club to hold all business sessions here as well as the semi-monthly meetings at which papers are read and discussed. In the rear is an alcove built for storing the stereopticon apparatus when not in use.

The third floor is given over to four comfortable bedrooms and a bath, and the front part of the house is reserved for a double bedroom and a good-sized room which is to be used as a committee room and headquarters for the secretary and treasurer. On the fourth floor is a 67x17-ft. room wherein will be installed a billiard table and shuffleboard, two additional bedrooms, a bath and a committee room.

Of the men who organized the club thirty years ago only three are still surviving as members. They are Wilfred Lewis, Charles A. Billin and M. R. Muckle, Jr. The idea of forming an Engineers' Club in Philadelphia grew from a series of social meetings held by the various engineers during the Centennial, but it did not take definite form until Dec. 17, 1877, when, at a meeting in Dr. Coleman Sellers' house, the club was organized, chiefly for social purposes. At first the meetings were held at the members' homes and were given over to good times with very little technical discussion. Collations were served and extracts from trade periodicals or newspapers were read and threshed over. The club prospered and soon took rooms in a building on the site of the present Broad St. Station, which they shared jointly with The American Institute of Architects. In four years the membership doubled and the club was compelled to seek larger quarters at 1522 Chestnut St. This clubroom was the arena for many debates on engineering topics of interest even to this day. Finally the little club gained such size that it looked about for a new home and selected the place in Girard St., occupying it Oct. 17, 1885. Like the others, the Girard St. clubhouse proved too small for the growing membership and its modern needs, so the more progressive members urged the purchase of a new home. Ten years' argument has at last resulted in the realization of their dreams, and the club to-day is in possession of one of the finest buildings of its kind in the country.

The Engineers' Club has always taken an active part in public discussions of peculiar interest to its members. It entertained Ferdinand De Lesseps upon his visit to this country in 1880, and all the delegates from the Engineering Society of France when they came here to the World's Fair in 1893.

That the progressive policy of the club is appreciated is shown by the fact that 124 new members have joined in the last two months, bringing the membership up to 595.

In taking over the house the club engaged Ballinger & Perrot as architects to direct the remodeling. In all $15,000 will be spent in alterations and furnishings.

Sewage Lift at Schenectady, N. Y.

An air lift has recently been installed in Schenectady, N. Y., to deliver the house sewage of a low-lying district across a ridge which would necessitate very heavy trenching for the main sewer and house connections, if a gravity system were installed. The installation is placed in a 26x11-ft. concrete chamber below the street surface and consists of four ejectors with a capacity of 100 gal. each per minute, operated by compressed air supplied through a storage tank by two compressors with a combined capacity of 340 cu. ft. of free air per minute each of which is driven by a 20-h.p. General Electric motor.

The ejectors are all connected to an 8-in. pipe header which leads to a 10-in. inlet pipe. As soon as an ejector is full a valve at its top is automatically tripped admitting compressed air from the storage tank at a pressure of about 30 lb. per square inch and the sewage is discharged through an 8-in. pipe leading to a gravity sewer about 1,900 ft. away. The vertical lift is about 21 ft. As soon as the ejector is emptied the compressed air is automatically cut off and the ejector is ready to operate again. The ejectors operate in rotation, the interval between ejections being determined by the sewage flow.

The motors and compressors are placed in one end of the chamber, the floor of which is raised 4½ ft. above that on which the ejectors rest. After each discharge the supply of air in the storage tank is automatically replenished; the tank is fitted with a pressure regulator and when the pressure falls below a predetermined point the pointer on the gauge makes an electric contact which causes compressed air to be admitted to a piston operating the starting rheostat of one of the motors. When the operation of the compressor has brought the pressure in the storage tank to the proper point the pointer on the regulator makes a second contact and the motor is automatically stopped. Under ordinary conditions only one motor and compressor is required to supply the tank and the second compressing outfit is held in reserve for use if the other should fail to operate. If this should happen the second motor would be put in operation automatically by the pressure regulator on the air tank which has a second electric contact point on its dial set for a lower pressure than the one first mentioned. It is expected that an attendant will visit the plant once or twice a week; an alarm system is also installed in a neighboring fire department house which will ring if both motors fail to operate.

The plant was built and installed by The Ellis Company, of New York, under the direction of Mr. Lewis B. Sebring, city engineer.

Letters to the Editor.

FAILURES OF LARGE STEEL BEAMS.

SIR: Regarding the failures of steel beams in your issue of December 28, 1907, the analyses given by your correspondent show that they were Bessemer beams running high in phosphorus and manganese. If the percentage of phosphorus in Bessemer beams exceeds 1/10 per cent., the material becomes brittle, this deterioration increasing very rapidly as the percentage increases. The unloading from the cars was probably all that was needed to rupture them. These fractures occur at times, not only in Bessemer beams, but in smaller sections of Bessemer steel, such as angles, rails, etc., and I don't think the size of the section had anything to do with the failure.

The largest size beams of open hearth steel are used in railroad bridges by the most conservative railroad companies, and they give, I believe, perfect satisfaction in the heaviest work.

The Engineers' Club of Philadelphia.

Yours very truly,

FRANK MILLER.

New York, Jan. 6.

TRACK ARRANGEMENTS AT MINOR STATIONS.

SIR: In connection with the subject of track lay-outs for small way-stations on single track lines, discussed in the paper by Mr. Frederick George Royal-Dawson, printed in your issue of Dec. 28, 1907, I beg to submit the attached diagrammatic sketch for a possible scheme for such a lay-out, making reasonable provision for growth:

In order that all the business at the station may be conveniently attended to by one man, the freight house and passenger station must be close together. They are shown in the sketch as two parts of one building.

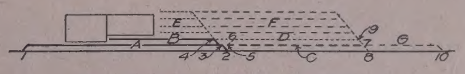
I have used the straight main track with passing siding *A* on the station side, all trains (whether they are to stop or not) to use the main except when this station is a meeting point. The space between tracks to be filled with cinders to form a platform. *B* is a freight siding, serving both as house-track and team-track. There are three switches, 1, 2, 3, two of them on the main line. This is all the trackage necessary if both local and through business are small.

When the through business increases to the point where it becomes desirable to clear the main track while the way freight is doing its switching at the station, a switching lead *C* must be constructed, dead-ended at 7. This lead serves also as a back-off track should three trains meet at this station. Both *A* and *C* must be at least equal to the maximum length of train liable to be side-tracked.

It is convenient to have the far end of *C* connected to the main at 7-8. There will then be three switches on the main track, and should it be desired to avoid this, remove cross-over 2-3 and extend track *B* to 9-7, putting in cross-over 5-6; 8-9 is now a short ladder track, 5-6-*D*-9-7 is the back-off track for a third train, and *C* becomes part of the passing siding. Either *C* or *D* may be used as a switching lead to serve track *B*.

At any time, either before or after the construction of *C*, additional yard-tracks *E* may be constructed, provided 4 is far enough from the freight house.

We still have only two breaks in the main-track iron, at 1 and 8, and as under the conditions assumed (way station on single track), the switches would in all probability be operated by the train crews and not from a tower, their remoteness from the station is no disadvantage.



Proposed Single-Track Station.

Should further enlargement of the yard be desired, continue track 8-9 as a ladder, running yard-tracks *F* parallel to the main, providing roadways for teams as required.

The construction of these tracks demands a lead *G* equal at least to one train length, connected to the main at 10. Cross-over 7-8 could then be removed if desired, but would in all probability be retained.

If a still further development of the yard should be required, a different and more elaborate type of lay-out would have to be used, but as a basis for further enlargement we have at least a regular system of parallel tracks to be developed in any way desired.

It must be remembered that such a plan as this can not be made and applied rigidly to all stations, even under the same conditions of traffic. Topography, highways, relative costs of different parcels of land, and similar influences, often control. But such a typical plan may be drawn, which may be modified in many ways and still retain its essential features.

The station and yard should, when possible, be placed on that side of the main track where the greater traffic originates, i. e., toward the town.

Yours very truly,

F. S. FOOTE, JR.

New York, Jan. 8.

ESTIMATING STEAM SHOVEL EXCAVATION.

SIR: The extensive use of the modern steam shovel in railroad betterment has offered many opportunities for testing the relative economy of handling heavy rock excavation, hardpan and loose earth by this means as compared with the same operations by derricks hoisting into carts, cars or other means of transportation. A great deal of information has been published giving these results, but very little of it stating the circumstances governing the work and dictating the choice of plant.

While it is often true that either of these two methods is equally applicable to a given cut or borrow-pit, it is sometimes imperative that one of the two must be used. One great feature governing the choice of methods where they are equally economical of operation in the cut, is the length of haul to the fill or spoil-bank.

The influence of this feature has led to practically universal use of engines and cars with steam-shovels with the exception of hauling small dump cars on narrow-gauge tracks with mules or horses. This last is economical when used on short haul downgrade, to dump from derricks using scale-boxes or buckets, enabling the loading of cars to go on forward while alternate train is on the fill.

In the case of steam-shovel excavation, especially in loose earth, high speed cannot be made with teams, and alternating train service must be resorted to if the maximum output is to be obtained.

These two operations being balanced, the remaining factor governing the output is the character of the dump or spoil-bank; as a chain's strength is its weakest link, so is the result determined by the speed of unloading and distributing the excavated material. So the plant must be increased by the addition of appliances to unload the cars and spread the material at the same speed as the excavation and transportation of the same. These three operations, then, are equally important influences in getting speed in the output, which is economy, and must all be considered in arriving at the probable cost of a proposed improvement.

A minor, but still important point when using train service, is the treatment of the track layout in pit and on dump in such a manner that the movement of the same while the shovel advances or after the fill is completed may be accomplished without interference with the schedule.

Obviously the greatest speed at the shovel will be obtained when a track has been prepared which will allow of the spotting of the cars beside the shovel in whole trains, rather than one or more at a time, so that the train is loaded with one movement, and the switching of cars, with consequent lost time, will be avoided. In a through cut this often necessitates the use of some heavy grades and even extra engine service in the pit to handle the trains, but is nevertheless the better method.

In a borrow-pit which can be opened from its side the greatest obstacle to this layout is usually in the matter of curves, which, however, can be eliminated in a great degree if the first cut is made to take out the points of the hill, when the track can be thrown to line and this obstruction to speedy train handling be done away with.

In a case where the material has some rock in isolated masses it may prove economical in the end to break it up by means of steam-drills and dynamiting in advance of the shovel to facilitate the handling when the shovel reaches it, it being difficult at certain seasons to maintain a night force on the drills so as to ensure a daily blast.

The plant, then, for speedy work, must be developed at three points, the shovel and pit trackage; the locomotives, cars, and, if flats or gondolas, an unloading device; and the dump or spoil-bank with its leveller.

This last operation is one which, during work over any length of time, will become variable and the organization of it requires daily attention from the superintendent beside making necessary some additional track work in advance to insure a quick change upon the completion of the first section. It may happen, also, that additional borrow may prove necessary. Evidently similar work in the new pit will have to be done to enable the shovel to make its change and resume excavation without delay. All of these items play an important part in the actual cost of steam shovel work, although one organization might find none of the foregoing track work necessary in a given month's time and the output therefore show a considerable advantage per yard over other similar periods.

Evidently the mechanical speed of the steam shovel is never the actual speed of the work, since the serving of cars for loading is part of the pit operation and this is exactly the result of the progress of the other two sections, those of the transportation and disposal. So the steam shovel's speed of excavation is the speed of the dump and the trains. It is occasionally possible to so organize the dump as to labor that it may at all times be kept prepared for unloading trains as fast as received from the shovel, under which circumstances the governing factor will be the speed of transportation. This last item is affected by the length of haul and the power of the locomotives, the length of haul being the greatest influence, being a variable factor as the fill progresses; while the question of power is one generally decided by plant already on hand or purchased at the start in view of the conditions first encountered.

This statement of the operation of a steam shovel will give some idea of the influences governing the speed of output and the yardage in any material, to be handled in any month. Obviously the easier the material is for the shovel to handle the greater the importance of the other two items of cost as regards their influence on the result.

Any cost of excavation, therefore, figured on the basis of so many dips per minute with a certain size dipper at 90 deg. to shovel, will ignore so many items of vital importance in the real expense that properly is chargeable to the unit cost, that it will have no value whatever in figuring on new bids unless the other two factors are so fully described as to allow a comparison to be made and the relative advantages and disadvantages compared.

It might be contended that the use of a trestle and dump cars would enable a shovel to be kept constantly at work, since the unloading time will then be considerably less than the loading. Against this fact is chargeable the expense necessary to keep the trestle safe from the racking of the same, due to the dumping of cars and the inevitable increase in the dump gang or equipment at the time when the widening of the fill upon reaching grade becomes necessary before the track can be thrown to the edge of the bank from the trestle. So even this ideal condition, in addition to its charge of first cost of trestle and erection, must carry these two future items before the completion of the work.

A published statement of the cost of steam shovel work from a well-known hand-book follows:—

Estimated Expense of Steam-Shovel Work.

1 Foreman	$5.00	per day
1 Engineman	4.00	" "
1 Craneman	3.50	" "
1 Fireman	2.00	" "
6 Pitmen, at $1.50	9.00	" "
1 Night watchman	2.50	" "
2 Engineers, 2 dinkeys, at $3.00	6.00	" "
2 Trainmen, at $2.00	4.00	" "
4 Dumpmen, at $1.50	6.00	" "
10 Trackmen, at $1.50	15.00	" "
1 Pumpman	2.50	" "
4 Blacksmiths, carpenters, repairing	12.00	" "
2 Waterboys, at $1.00	2.00	" "
Supplies for repairs	6.00	" "
Coal, 1.3 tons, 1 shovel, at $4.00	5.20	" "
Coal, 0.6 ton, 2 dinkeys, at $4.00	2.40	" "
Coal, 0.2 ton, 1 pump on water, at $4.00	0.80	" "
Oil and waste	1.00	" "
15% interest and depreciation on $15,000 plant, distributed over 150 days worked	15.00	" "
Total, 10-hour day	$103.90	" "

On the basis of the daily output of a 1½-yd. shovel being 900 cu. yd. the cost is given as slightly less than 12 cents per cubic yard. With the day's work in tough material as 600 cu. yd., the cost is 17 cents per cubic yard.

This cost assumes one of two things; the existence of a trestle before the commencement of work, in use possibly for regular train service and being filled in to avoid repairs, or a trestle built for the purpose of making the fill and paid for outside of the yardage price, since no account is taken in figuring this yardage price of the cost of timber, its delivery on the ground, or labor of framing, erecting and bracing. This is a variable item governed solely by the conditions, and in a very deep fill it might prove an item causing an appreciable increase in the unit cost per yard.

It is not so long ago that an account was given of a fill across a valley, with precipitous sides, made for a railroad in the western part of the United States. The method adopted required the erection of a trestle of great height and it proved economical to use steel bents in towers with girder spans, all of the steel being buried except girders and floor system, which could be saved. It is evident that in this case a separate contract must have been made, covering the fabrication and erection of this trestle, against which cost would be a credit of the scrap price of the girders, etc., at the end of the work. Also masonry footings were no doubt used to insure stability. All of this preliminary expense would be directly chargeable to the unit price unless it is covered as a separate item or is a completed improvement. Even in this case it would seem rightfully a part of the unit cost, being the method of disposal of the material and directly affecting the size of the dump gang and the amount of track labor.

Another feature of this part of the work would arise were the trestle a part of the main line of a railway company, with a standard gauge track upon it, making it impossible to use narrow-gauge dinkeys and necessitating the hire or purchase of standard rolling stock to handle material. Especially would this prove a factor introducing serious delays due to main line traffic, as the steam shovel schedule would rarely avoid the interference with that of the main line trains and would necessarily be of secondary importance to it.

This one feature alone might easily prove of equal influence on the size of a day's output with the difference in material, which is stated as being but little under 50 per cent. The writer was recently informed that in a case where a main line track was raised about 12 ft. under heavy freight and infrequent passenger traffic, with a short haul from a borrow-pit of fine mica sand, the cost, exclusive of repairs to plant, plant itself, etc., was 22 cents per yard for all labor, although on some days the output was 2,000 cu. yd.

The difference in these items is but a single instance of how mistaken a method is which uses published cost data without full information as to the conditions under which they applied. Even then it is evident that only a judgment trained by long experience could safely use them. These facts showing the difficult conditions of fill, even where material and haul were favorable, would seem to justify the writer's opinion that no set of costs on this work can be any criterion for guidance on other work without a full description of conditions and the exercise of the best of judgment.

M. A. O. Stilson.

Brick Chambers for Stop Cocks on water mains have been adopted by the Water and Sewerage Department, of St. John, N. B., according to Supt. Wm. Murdoch. Until recently these cocks have been merely buried in the ground, with a deal box only large enough for the key, extending from the spindle to the surface. With that method, when the packing fails or any other repairs are required, a hole must be dug. Under the new system a brick chamber of elliptical plan, 3 x 4 ft., tapering as it ascends and terminating on the surface in a circular hole 2 ft. in diameter with an iron cover, is used. This gives free access to the gate at any time.